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THE HAWAIIAN PLANTERS' RECORD

VOL. XXXVII

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THE HAWAIIAN PLANTERS' RECORD

Vol. XXXVII FIRST QUARTER, 1933 No. 1

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the plantations of the Hawaiian Sugar Planters' Association.

In This Issue:

Introduction of Tropical American Toad:

Description is given of an insectivorous toad with discussion of its introduction to Hawaii, habits, establishment and probable value together with an account of its history and usefulness in Porto Rico.

Improved Arsenical Dust for Armyworms:

Arsenical dusts containing a small amount of neutral mineral oil have proven superior to dusts used previously against armyworms, because of better sticking qualities. Formulae are included with method of preparation and results of tests.

Introduction and Habits of New Grasshopper Parasite:

An account of the discovery in Malaya of an egg parasite of the Chinese grasshopper is presented with an outline of its habits, introduction to Hawaii, local breeding, distribution and establishment.

Some Food Habits of the Mongoose:

A detailed enumeration of the food eaten by a number of caged individuals and of intestinal contents from this animal in the field, indicates a wide variety of material eaten, with a strong preference for animal rather than vegetable food.

Annual Synopsis of Mill Data:

The Annual Synopsis of Mill Data for 1932 is presented. The statistical data and discussion of technical results are in much the same form as in previous years.

Notes on Seedlings on Kauai:

Several of the seedlings which are being tested on Kauai are discussed.

Scales and Their Troubles:

A discussion on scales is given by the inspector employed by the Association under the auspices of the Raw Sugar Technical Committee. The weak and strong points of certain types of scales are dealt with and practical hints are given on keeping scales in good working condition.

The Bindweed:

An illustrated account is given of the appearance and habits of the California morning-glory or bindweed, a cane field pest of potentially great importance, and suggestions are made as to methods of control.

Chromosomes of Sugar Cane:

Illustrations of sugar cane chromosomes are presented with a discussion of the role of chromosomes in the mechanism of heredity.

Measuring Production in Terms of Temperature:

The marked influence of temperature on cane growth is well recognized in these islands. In the present paper an attempt has been made to devise a quantitative measure of temperature as affecting cane growth and yield. It is shown that with the help of this new measure called the "day-degree" satisfactory estimates of total effective warmth for different crops may be easily obtained.

It is suggested that this new measure, approximate though it may be, provides us, nevertheless, with a strong tool, an intelligent use of which may aid our future agricultural progress.

Lime Versus No Lime:

In summarizing the results of lime experiments, little or no evidence has been found that lime has affected the cane tonnage. It would seem to be more than a coincidence that in practically all cases the quality ratio was slightly better in the no lime plots. A further study of the quality ratio figures shows that the Brix, polarization and purity are lower on the limed than on the unlimed plots. This holds for the acid wet and semi-dry areas on Hawaii and Kauai, as well as on the more or less neutral irrigated lands of Oahu and Maui.

The Effect of Various Intensities of Light on the Growth of the H 109 Variety of Sugar Cane:

The results of a preliminary experiment on the effects of various intensities of light on the growth of H 109 cane are given. With decreased light intensity the height of the primary stalks was increased, secondary shoot development was completely retarded, the leaves became narrow, elongated, and brittle, and the root development was greatly reduced. The dry matter of the plants was also reduced with decreased light intensity. With decreased light the chlorophyll content of the leaves was increased up to a certain point, but with the further decreased light the chlorophyll content was reduced.

Invertase Activity in Sugar Cane:

Data are presented which indicate that the activity of the enzyme invertase is seriously affected by a deficiency of potash in sugar cane.

The results herein reported offer indirect evidence that sucrose in the sugar cane plant is synthesized by invertase.

P. O. J. 36 on the Big Island

A point of real interest in cane culture on the island of Hawaii is the extent to which the cane variety P. O. J. 36 is being spread. The planting programs of 1932 caused the seventeen plantations of that island to place an additional area of 3,797 acres under P. O. J. 36, bringing the total area for the 1933 and 1934 crops to 10,181 acres.

The plantation with the largest area of P. O. J. 36 at the beginning of this year is the Onomea Sugar Company, with 1,931 acres; followed by Hutchinson Sugar Plantation Company, with 1,154 acres. Thus is indicated the suitability of this variety for both wet and dry areas of the Big Island. Third comes Paauhau Sugar Plantation Company, with 1,116 acres; fourth, Olaa Sugar Company, with 1,087 acres; fifth, we have Hakalau Plantation Company, with 1,010 acres; sixth, Honomu Sugar Company, with 1,006 acres; and seventh, Honokaa Sugar Company, with 971 acres. The remaining plantations have smaller areas varying from 379 acres at the Hawaiian Agricultural Company, to 16 acres at Kaiwiki Sugar Company.

If we consider this expansion of P. O. J. 36 on the part of the different plantations in terms of the percentage of the total cane area that has been placed in this Java seedling, we find another interesting listing, which gives Honomu first place, with 30% of their total area in P. O. J. 36, followed by Onomea, with 24.5%; Paauhau, with 24.4%; Hutchinson, with 21%; Hakalau, with 15.5%. Studied from this angle, the five Brewer plantations named above hold the lead

by a good margin. Sixth comes Honokaa, with 10.3%; then Niulii, with 8%; Pepeekeo, with 7.8%; Olaa, with 7%. Then come Hilo Sugar Company, with 4.8%; Union Mill, with 4.3%; Hawaiian Agricultural Company, with 3.8%; Kohala Sugar Company, with 3.4%; Laupahoehoe Sugar Company, with 2.7%; Hamakua Mill, with 2.2%; Waiakea Mill, with 0.8%; and Kaiwiki, with 0.4%.

P. O. J. 36 AREAS IN 1933 AND 1934 CROPS

Plantation	P. O. J. 36 Area	Total Area in Cane	% of Total Area in P. O. J. 36
Hakalau Plantation Company	1,010	6,494	15.5
Hamakua Mill Company	140	6,272	2.2
Hawaiian Agricultural Company	379	10,000	3.8
Hilo Sugar Company	374	7,817	4.8
Honokaa Sugar Company	971	9,393	10.3
Honomu Sugar Company	1,006	3,312	30.0
Hutchinson Sugar Plantation Company	1,154	5,380	21.0
Kaiwiki Sugar Company	16	4,613	0.4
Kohala Sugar Company	347	10,115	3.4
Laupahoehoe Sugar Company	170	6,415	2.7
Niulii Mill & Plantation	196	2,450	8.0
Olaa Sugar Company	1,087	15,618	7.0
Onomea Sugar Company	1,931	7,876	24.5
Paauhau Sugar Plantation Company	1,116	4,563	24.4
Pepeekeo Sugar Company	286	3,682	7.8
Union Mill Company	132	3,054	4.3
Waiakea Mill Company	46	5,794	0.8

The plantations on Hawaii will spread P. O. J. 36 still further this year, and from the forecasts of 1933 plantings that are beginning to be returned it is evident that the area of this cane will be extended by many hundreds of acres.

H. P. A.

Improved Arsenical Dust for Armyworms

By C. E. Pemberton

During the summer of 1932, field tests with arsenical dusts, into which had been incorporated a small percentage of neutral mineral oil, were made in an effort to improve the sticking qualities of these dusts. The oiled dusts adhered to the cane leaves distinctly better than the others. The final formulae as now recommended are as follows:

Finely powdered raw rock phosphate	6 parts
White arsenic	1 part
Neutral mineral oil	5 per cent
or	
Finely powdered raw rock phosphate	5 parts
Powdered arsenate of lead	1 part
Neutral mineral oil	5 per cent

Proportions by weight.

The particular dust used in the tests was prepared by the Pacific Guano and Fertilizer Company. The oil is described as Shell Zero Oil and is a commercial neutral spray oil. Flint and Farrar*, who have developed mineral oil insecticide dusts in Illinois, found that mineral oils of from 80 to 110 seconds viscosity were most desirable for dusting mixtures. The oil is inert and is not injurious to the cane leaves in the proportions used. It is best mixed into the finally prepared dust by atomizing or spraying it under considerable pressure over the dust while the latter is being stirred or agitated. In the preparation of small amounts the oil can be sprayed over the thoroughly stirred dust with a flit gun or simple hand sprayer. The best method for thoroughly mixing the oil is to spray it into a hopper or drum while the dust is slowly added.

Oiled dusts do not pack in storage nor deteriorate.

Field tests at Hilo Sugar Company by Dr. F. X. Williams, and in Manoa Valley by R. H. Van Zwaluwenburg, at times when considerable rain fell, gave distinctly better adhering qualities of the oiled dusts over others.

Analyses by the chemistry department of the residue left on cane leaves which had been dusted with several arsenic mixtures by Mr. Van Zwaluwenburg in Manoa Valley in July, 1932, indicated that oiled dusts adhered much better than would appear to the eye in field examinations. Leaf samples from the field which had been dusted with one part white arsenic and six parts raw rock phosphate to which 5 per cent by weight of mineral oil had been added, showed in all samples taken over twice as much arsenic present as on leaf samples receiving any other mixture. In some cases over three times as much arsenic was

* The Use of Mineral Oils for Better Dusts. *Journal Economic Entomology*, Vol. XXV, pp. 269-271, April, 1932.

present. These tests compared white arsenic and raw rock phosphate mixtures with and without oil; calcium arsenate and raw rock phosphate mixtures with and without one part cement, and thirdly white arsenic and raw rock phosphate mixtures with and without one part cement. All of the tests received over two inches of rainfall before sampling began.

Notes on Seedlings—Kauai

28-3540 is attracting particular interest at Kekaha Sugar Company. The plantation has planted approximately 40 acres of this seedling on their Mana flats and in all cases it is making a satisfactory growth.

This is a seedling of Yellow Caledonia crossed with H 109. It is completely eye spot resistant, but takes brown stripe in the locations where this disease is prevalent. In general, it produces a stalk slightly larger than H 109 and has an upright habit of growth. It ratoons well.

28-2055 is rapidly coming to the front at Koloa Sugar Company. The preliminary yields from the plant crop were most satisfactory and the ratoons have been most vigorous and economical in weed control.

This seedling is a half-sister of P. O. J. 2878 in that it has the same female parent. The male parent is a Caledonia hybrid, 26 C 270. It may be considered commercially resistant to eye spot disease in that it shows only an occasional runner. The stalks of this seedling are of medium size and tend to tassel heavily. Strong lalas develop soon after the tassels emerge.

30-2417 is a new seedling which is attracting great interest wherever it is planted. It germinates well, develops large, clean stalks which show a rapid rate of growth. Eye spot and brown stripe are no problem with this seedling. Little is known about the juice quality of this new seedling yet, although the parentage (28-674 [POJ 2364 × 26 C 270] × H 456) would indicate that this should be good.

Co. 290 is making a rank growth wherever it is planted. On all the plantations on Kauai where eye spot is prevalent the disease was most severe on Co. 290. In three cases it was found necessary to dig the cane out to prevent the spread of the disease from these plots to the adjoining fields.

C. G. L.

Introduction to Hawaii and Habits of Egg Parasite of Chinese Grasshopper

By C. E. Pemberton

The Chinese grasshopper *Oxya chinensis* (Thun.) is undoubtedly of Oriental or Indo-Malayan origin. The genus Oxya is known to contain some 30 species, most of which occur in India or Indo-Malayan regions. The species *chinensis* most probably reached Hawaii in the egg stage in soil brought to Hawaii by Orientals during the early days of labor importations.

In undertaking the problem of finding parasites of this grasshopper in 1930, the Malay Peninsula was chosen for study because *O. chinensis* was known to occur there, in company with a half dozen or more species of the same genus.

The writer departed for Malay on July 8, 1930, and reached Serdang, Selangor, Federated Malay States, on August 12, where quarters were obtained near virgin forest and open cultivated land through the kindness of the Department of Agriculture, F. M. S. This region lies about 175 miles up the Peninsula from Singapore. Oxya grasshoppers though present were never abundant. It was seldom possible to find more than 40 in a day's time though in rice fields in Malaya they are said to become abundant at times.

Field cages open at the bottom and resting directly on the ground and covered with large mesh wire screen were set out in grassy land. These were stocked with grasshoppers, which immediately started laying their eggs in the soil under the cages. The eggs were periodically removed and held in stoppered vials for observation. After seven weeks of such work two species of parasites were reared from the Oxya eggs. These parasites, since described and named by P. H. Timberlake as *Scelio serdangensis* and *Scelio pembertoni,* which are new species, were reared in quantity between October, 1930, and April, 1931, and shipped to Honolulu. Thirteen shipments of parasitized grasshopper eggs were made, from which 2600 parasites were successfully reared in Honolulu by O. H. Swezey and his associates.

Between January, 1931, and January, 1933, a total of 44,300 parasites have been reared in the laboratory in Honolulu on *Oxya chinensis* eggs and distributed to sugar plantations in Hawaii. Most of the distribution has been of the species *Scelio pembertoni.* The other species *S. serdangensis* died out in the cultures early in 1931. The breeding work since August, 1932, has been conducted by J. S. Rosa.

The extensive breeding and distribution of the parasites has already resulted in the known establishment of the species *S. pembertoni* in several localities on the island of Oahu and at Hilo Sugar Company on the island of Hawaii. The life history of this species may be briefly summarized as follows:

The female searches over the ground for spots where the grasshopper has deposited egg pods. Upon locating one she works through the loose soil particles

Malayan parasite of Chinese grasshopper.

1. Adult female. × 9.

2. Grasshopper egg-pod from which parasites have hatched. × 5.

3. Parasite inserting eggs in grasshopper egg-pod. × 5.

which more or less cover the mass of 15 to 25 eggs and inserts her ovipositor therein usually in the manner and position indicated in Fig. 3. She places one egg each in several or all of the grasshopper eggs in the egg pod. In order to accomplish this the parasite may remain in the ground over the grasshopper egg mass for from a half hour to sometimes 4 or 5 hours with hardly any change of position. Occasionally more than one egg will be placed in a single grasshopper egg. In such cases all of the parasite eggs hatch but only one parasite ultimately develops in the egg.

The parasite lives about two weeks and deposits an average total of approximately 50 eggs.

From 25 to 40 or 50 days after the eggs are laid, depending on the temperature, the parasites hatch from the Oxya egg pod. They escape by gnawing their way out. An egg pod from which parasites have hatched is shown in Fig. 2 and the parasite, much enlarged, in Fig. 1.

Almost immediately after the female parasite hatches from a grasshopper egg she is capable of ovipositing. An abundance of mature eggs are present in the ovaries at this time. The parasite successfully parasitizes grasshopper eggs of all ages. Hopper eggs almost ready to hatch can be successfully parasitized as well as those newly laid or at all ages between the two extremes.

If the parasite cannot find eggs for at least two weeks after hatching she still is able to successfully parasitize eggs for a day or two before dying.

Females are usually much more numerous than males.

Mr. Swezey has shown that the development period of the grasshopper from egg to adult averages in Hawaii from 12 to 16 weeks. From the above summary it is seen that the period required for development of the parasite, from egg to adult, varies from 4 to 7 weeks with an average of about 5 weeks. The parasite thus requires only about one-third as much time to pass through a cycle as the grasshopper.

A more detailed account of this parasite has been prepared for publication in the *Proceedings of the Hawaiian Entomological Society* for the year 1932.

Scales and Their Troubles

By C. P. Hinman

A desirable scale is one which will give accurate weight of an article and continue to give accurate weight over a reasonable period of time.

To give such results, the scale must be suited to the work it has to do. It must be of sufficient capacity to withstand the load, plus the shock attending the placing of the load on the scale. All scales to which the load is roughly applied should have a rated capacity of ten times the amount of the usual load weighed.

Cane-car scales of this rating will stand up under long years of service, giving a continuous correct weight. For example, the scales at Olaa, Paauhau and Honokaa have been in service for more than 30 years and no repairs have yet been necessary to the main levers. On the other hand, the 10-ton rated capacity "A" lever scales, at a number of mills where they are used for weighing loaded cane cars, have not stood up to accuracy more than two years without adjustment of main levers. At three plantations, scales which were taken out and refitted with new steels in 1928 were so worn that they had to be taken out and reground in 1932. Four years of service for these scales against 30 years, and more to come, for the Olaa scales.

The juice scales used in all but two of the mills are of a single make. Some of these have been in service more than 20 years with no repairs to the main levers. They are the best scales for this work that can be bought today. The type recording beam used on these scales requires repairs at least once a year. The rollers, track, stamping device, and the poise latch are constantly wearing, changing the efficiency and accuracy of the scale. The poise on the average juice scale travels something like 700 feet every 24 hours on rollers 1⅛ inches in diameter, making about 30 miles of travel in a grinding season.

The sugar sacking scale which has shown the best results in the past four years is a 1,000-pound capacity portable scale. This scale has ball-bearings under the platform which keep the platform clear of the frame, and the scale will give accurate weights when not exactly level. Other scales having check rods to hold the platform from the frame have not given satisfaction. The flat bearing at the front of the platform permits the short lever to slide under it, changing the relative position of the two main levers, and the multiple of the scale is changed, giving weights over or under the true weight. The rough placing of a sack of sugar on such scales will cause the change mentioned.

Other scales having indicators to mark the high or low balance of the weigh-beam have been tried in two or three mills. Like all scales, their sensitiveness depends upon their cleanliness. This type of scale is good, beyond question, but its cost is fifteen times or more than that of the 1,000-pound scale, mentioned in the preceding paragraph, and the accuracy of the weight is dependent upon the man doing the weighing. The human element cannot be removed from sugar sacking at present with any degree of improvement. The automatic sugar scale

is not a success in raw sugar sacking and reports will show that better weights are obtained on the plain portable scale with a careful man doing the weighing.

In cane-car weighing, the human element has been largely removed at many mills by attaching the weightograph to the weighbeam. The weightograph automatically balances the platform load and the correct weight is shown in figures of light on a ground glass panel similar to that of a movie screen. The combined weight shown there is copied by the weighman on the weighsheet. Of the numbers of these machines in use at the mills for years past there are no complaints and each owner is well satisfied with them.

The old style weighbeam required the placing of weights at the end of the beam and sliding a poise to a point where the beam balanced. The several weights must then be combined into one for entry. The type-recording beam combined the weights into one and stamped them on a cardboard strip. In neither case is there any assurance that the beam was in balance at the time the reading was made. The balancing of the beam was entirely dependent upon the reliability of the weighman. The stamped weightticket meant that the poise was at that location when the ticket was stamped. It may have been hundreds of pounds above or below the true weight. The weightograph eliminates this doubt. The figures on the screen are more easily copied than it would be to invent another set of figures. In addition to this, a device has been granted a patent which will automatically make a record of the weights shown on the weightograph, entirely eliminating the human element. This may be placed on the market before the next grinding season.

Juice weight accuracy would be greatly improved by the attachment of the weightograph to juice scales.

The following is a summary of the work during the past offseason up to December 1:

The mills were a month late shutting down in 1932, making it necessary to work Sundays and some nights and longer hours than usual in order to service all the scales at all the plantations.

Of the 40 mills and railroads to be serviced this year, up to December 1, 36 of them had been serviced. At these 36 plantations and railroads, 301 scales were serviced.

All scales were left weighing correct within the tolerance. The tolerance is the permissible error, over or under the true weight, allowed by the United States Bureau of Standards, and a scale weighing within the tolerance is assumed to be correct in all States on the mainland. The tolerance, or permissible error on plantation mill scales, is one-tenth of 1 per cent.

Sixty-eight standard 50-pound test weights were compared with the master weight and made correct.

Reports to the plantation managers, and the Experiment Station, have been made on each scale serviced or inspected. Certificates of the accurate condition of cane-car scales and railroad scales have been issued to the plantation managers, showing date of final test.

Some Food Habits of the Mongoose

During August, 1932, we were informed, through J. W. Waldron, of mongoose injury to bananas at the property of Miss Wilhelmina Tenney at Heeia, Oahu. Miss Tenney had observed this animal actually carrying bananas away. In Trinidad, bananas have been sometimes used successfully as bait in mongoose traps. To further test this and other habits of the animal a number were caged at the Waipio substation and fed a varied diet. This was greatly facilitated through the help of F. C. Denison and his staff at Waipio, who conducted most of the feeding tests.

It was found that the mongoose would not eat sugar cane even when split, nor such fruit as papaias and oranges, but that ripe bananas and their skins would be eaten, especially the skins at times when more acceptable food was not available. Fresh coconut meat if removed from the shell is eaten in small amounts, but rancid coconut is avoided. Bread, rats, mice, eggs (no shells), birds, fish, live crabs, centipedes, cockroaches, all insects, frogs, earthworms, and meat of all sorts were usually taken with relish. They would not eat millipedes. A good deal of water was taken. When confined together some of the less pugnacious individuals were killed and eaten by their associates.

At Oahu Sugar Company we frequently find remains of Anomala adults in the mongoose excrement together with mouse and rat hair and other insects such as grasshoppers and cockroaches.

Mongoose *Herpestes birmanicus*. About one-quarter natural size.

As reported on page 42, Bulletin No. 17, Entomological Series, of this Station, the writer made 356 examinations at Honokaa, Hawaii, in 1924, to determine the food consumed in the field by the mongoose and found in all cases nothing but the remains of rats, mice, or insects, alone or in combination.

During 1915-1919 and 1920, O. H. Swezey made a number of examinations of mongoose excrement from Palolo Ridge, Oahu (near the crater), Waiau Ridge, Oahu, Mt. Tantalus, Oahu, the H. S. P. A. Experiment Station, Honolulu, Waianae above the plantation, and upper Moanalua Valley. In every case he found either insects, spiders or rodent parts, or combinations of them. The findings included remains of crickets, grasshoppers, the locustid *Conocephalus saltater,* rodent hair or bones, the grasshopper *Oxya chinensis,* Scotorythra caterpillars, spiders, the rose beetle *Adoretus sinicus,* the ground beetle *Gonocephalum serriatum,* a few honey bees and the large wasp Polistes (probably hebraeus). He found in a few cases guava seeds and bits of grass.

C. E. P.

Studies of the Invertase of Sugar Cane

A Preliminary Report*

By Constance E. Hartt

Oparin and Kurssanov (1) report the synthesis of a sugar identified as sucrose from an invert sugar solution in the presence of phosphate salts by the simultaneous action of the invertase and phosphatase of yeast. This work has a direct bearing upon the results recently obtained in connection with studies dealing with some effects of potassium upon the growth, chemical composition and enzyme activity of sugar cane, which will be reported in full elsewhere.

In a previous report (2) evidence was presented indicating that sugar cane plants deficient in potassium have weaker invertase than similar plants supplied with an adequate amount of potash. These experiments have been repeated and elaborated during the past year.

Sugar cane, variety H 109, grown in quartz sand and supplied with a complete nutrient solution containing 87.9 p.p.m. K, when tested for invertase showed an activity greater than that in plants deficient in potassium, in both stems and blades. The activity in stems was affected more severely by a lack of potassium than that in blades. Invertase was determined by the method described in the former paper, using the Bertrand titration. The results are presented in the table, in which the figures for invertase activity are expressed in cubic centimeters of N/20 $KMnO_4$.

* This research was conducted in 1931-1932 at the Experiment Station of the Hawaiian Sugar Planters' Association, with the aid of the Sarah Berliner Research Fellowship of the American Association of University Women.

K DEFICIENCY AND INVERTASE ACTIVITY

Series No. of Plant	p.p.m. K in Soln.	% K		Invertase–Unbuffered		Intertase at pH 4.4	
		Blades	Stems	Blades	Stems	Blades	Stems
1	87.9	2.175	1.504	25.00	22.16	36.08	23.04
5	0.0	0.501	0.278	17.71	7.97	36.69	13.57

It is interesting that the invertase activity in the blades was equalized at the optimum reaction (pH 4.4) while that of the stems was not.

Sugar determinations were performed and derangements in the transformations of hexoses and sucrose were noted in the plants deficient in potassium, correlated with their weak invertase activity.

In another experiment, using variety P. O. J. 2878, it was found that the invertase activity of the green leaf portion of the stalk was double that of the dry leaf part of the stem. Green leaf cane may be defined as that portion of the stalk to which green leaves are attached; the part which bears only dry leaves is called dry leaf cane. It is in the green leaf part of the stem that the most active storage of sucrose occurs. Some additional storage takes place in the dry leaf cane. The invertase of the blades was found to be equal in activity to that of the green leaf cane. It is evident that wherever sucrose is actively formed and stored, the activity of invertase is great, whereas where the process of storage is practically completed, invertase decreases in activity.

For many years the order of the formation of sugars in the plant has been a moot question. Clements (3) has recently stated that physiologists seem to agree now that the simple sugars are the first sugars formed by plants; and Priestley (4) concluded that the hexoses are the primary sugars of photosynthesis. The results of the present study also support this view. If sucrose were the first sugar formed in photosynthesis in sugar cane, then it must be considered that all the glucose and fructose in the blades is formed by the inversion of sucrose. If so, then what is the explanation of the greater percentage of reducing sugars and lower percentage of sucrose, with equal total sugars, in the potassium-deficient blades, which had the weakest invertase activity?

It would seem that these results offer indirect evidence that sucrose in the sugar cane plant is synthesized by invertase.

Further studies of the factors affecting the activity of invertase in sugar cane are now under way.

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Introduction to Hawaii of the Tropical American Toad *Bufo marinus*

By C. E. Pemberton

During March and April, 1932, the writer collected in Porto Rico and imported to Hawaii, 154 toads of the species *Bufo marinus* (Linné) of which 149 arrived in good condition and were liberated in upper Manoa Valley and at Waipio on the island of Oahu. The toads were transported in four separate lots, each lot being confined in a wooden box nearly filled with wood shavings or excelsior. The first three consignments were sent by regular express and the fourth crate personally conveyed by airplane from Porto Rico to Florida, by transcontinental train from Florida to California and thence by steamer to Honolulu. The first three lots arrived in Honolulu after a journey of from 16 to 19 days and the fourth reached its destination in 13 days. No food was given them en route. The packing material in each box was thoroughly moistened in Porto Rico before shipment.

Bufo marinus. One-half natural size.

The toads were liberated at Waipio on April 22 and 30 and in Manoa Valley on April 18 and 29. For several months after liberation some of the original toads have been seen at various places near by but in a few cases individuals have been observed several hundred yards distant from the points of liberation. On August 31, 1932, several young toads were seen at Waipio and from then on they have been readily found in this locality. This is fair indication that the species has become established. It will probably be a year or more before they have become sufficiently numerous to be moved in quantity to other portions of Hawaii.

Bufo marinus is native to tropical America and is known to occur from Mexico to northern Argentina, including the island of Trinidad. It has been purposely distributed by man in modern times to a number of the West Indian islands and Bermuda because of its insectivorous habits. Wherever introduced it usually remains comparatively inconspicuous for a few years and then appears in great numbers and continues abundant. The Federal Agricultural Experiment Station of Porto Rico introduced it to that island from Barbados in 1920, and in 1924 R. Menéndez Ramos, director of the Insular Experiment Station at Rio Piedras, P. R., introduced 40 more of the same toad from the island of Jamaica. The toads increased very rapidly, for in the Annual Report of the Porto Rico Agricultural Experiment Station for 1926, the director, D. W. May, stated that the toads had "increased so rapidly that now they are found in great numbers in the western end of the island." He stated further that "Planters in this part of the island report lessened depredations of the changa" (mole cricket) "and white grubs" (allied to Anomala and Adoretus) "as a probable result of the introduction."

This toad will eat almost any insect that comes within its vision, which includes beetles, moths, wasps, flies, caterpillars, mosquitoes, etc. It is mostly nocturnal, hiding generally by day in holes in the ground. Occasionally they can be seen in the daytime, especially when very numerous in a particular locality. They have become very abundant in Porto Rican cane fields and are credited today with helping considerably in checking certain pests of cane. The tadpole stage is said to be of short duration compared with that of most other toads and frogs.

This toad when full grown will measure from 6 to 7 inches in body length. There is every possibility that it will become very numerous in Hawaii because of the absence of many natural enemies which it normally contends with in its native habitat. It was found to thrive in Porto Rico even in cane lands occupying the dry sections of the island. Small ponds, reservoirs and temporary pools during short rainy seasons seem sufficient to enable it to multiply rapidly and radiate into agricultural lands away from water.

Lime Versus No Lime

In summarizing the results of these 19 lime experiments, we find little or no evidence that the lime has affected the cane tonnage, but it would seem to be more than a striking coincidence that in practically all cases the quality ratio was slightly better in the no lime plots. Further study of the components of these Q.R. figures shows that the Brix, polarization and purity are lower on the limed than on the unlimed plots. This holds for the acid wet, and acid semi-dry areas on the islands of Hawaii and Kauai as well as on the more or less neutral irrigated fields on Oahu and Maui.

Following this hint we are planning work to see what effect, if any, will changing the pH of coral soils with sulphur, or of acid soils with lime have on the juices. A careful study of the plant itself will be made. Generally the low coral flats have poorer juices. Is this in any way related to lime?

However, we must not overlook the fact that lime is one of the absolutely essential nutrients of plants, and in connection with our studies of the effects of lime on cane juices we must also concern ourselves with maintaining adequate reserves of calcium to be drawn upon by our crops.

A COMPARISON OF JUICES WITH AND WITHOUT LIME

	Expt.	Brix		Pol.		Pur.		Q. R.	
Plantation	No.	Lime	No Lime	Lime	No Lime	Lime	No Lime	Lime	No Lime
Hilo Sugar Co.....	27	19.26	19.57	17.12	17.48	88.92	89.32	7.76	7.60
Honomu Sugar Co...	22	12.75	13.93	10.58	12.12	83.0	87.0	13.23	11.14
" ...	23	15.70	17.03	13.36	14.97	85.1	87.9	10.22	8.89
Pepeekeo Sugar Co..	5	18.82	18.62	17.03	16.67	90.44	89.53	7.74	7.94
Hakalau Plt. Co....	17	18.10	18.3	16.0	16.2	88.4	88.5	8.34	8.24
Totals		84.63	87.45	74.09	77.44				
True Averages		16.93	17.49	14.82	15.44	87.5	88.6	9.01	8.55
Kaiwiki Sugar Co...	1	19.7	19.9	17.75	17.90	90.1	89.9	7.44	7.22
" ...	4	19.3	19.8	17.3	18.0	89.6	90.9	7.63	7.26
Hamakua Mill Co...	1	18.13	18.5	16.26	16.85	89.7	91.03	7.90	7.55
Paauhau Sug. Plt. Co.	10	17.31	17.48	15.71	15.88	90.76	90.85	8.30	8.20
Niulii Mill & Plt. Co.	1	17.88	= 17.87	15.70	15.84	87.81	88.64	8.65	8.43
Union Mill Co.....	21	18.93	19.59	16.90	17.62	89.28	89.95	7.88	7.53
Totals		111.25	113.14	99.62	102.09				
True Averages		18.54	18.86	16.60	17.02	89.5	90.2	7.93	7.70
Kilauea Sug. Plt. Co.	4	17.27	17.63	15.06	15.31	87.2	86.6	8.80	8.68
Lihue Plantation Co.	11	14.66	14.5	11.72	= 11.7	79.94	80.7	12.40	12.30
Grove Farm Co.....	8	18.09	17.93	15.77	= 15.74	87.2	87.8	8.43	= 8.41
Koloa Sugar Co.....	30	14.62	14.70	12.12	12.23	82.8	83.2	11.55	11.45
"	20	15.3	15.6	11.93	12.67	77.9	81.2	12.38	11.08
Totals		79.94	80.36	66.60	67.65				
True Averages		15.99	16.07	13.32	13.53	83.3	84.2	10.36	10.12
Wailuku Sugar Co..	1	20.93	21.81	18.82	19.66	89.92	90.18	6.97	6.66
Oahu Sugar Co.....	8	16.5	16.9	14.11	14.66	85.54	86.16	9.66	9.24
"	17	15.5	15.6	12.45	12.58	80.18	80.9	11.18	11.06
Totals		52.93	54.31	45.38	46.90				
True Averages		17.64	18.10	15.13	15.63	85.8	86.4	8.94	8.61
Grand Average		17.36	17.67	15.09	15.50	86.56	87.42	9.21	8.85

SUMMARY—NO LIME PLOTS—JUICE

	Better	Equal	Poorer
Brix	15	1	3
Polarization	18	2	1
Purity	17	1	3
Q. R.	18	1	2

NOTE—Best underscored. Equal sign used when no difference.

LIME VS. NO LIME

Plantation	Expt. No.	Q. R. Lime	Q. R. No Lime	Sugar per Acre Lime	Sugar per Acre No Lime	Gain or Loss Sugar for Lime Plots	Variety
Hilo Sugar Co.	27	7.76	7.60	10.79	10.01	+0.78	Y. C.
Honomu Sugar Company	22	13.23	11.14	4.70	5.39	— .69	D 1135
"	23	10.22	8.89	7.10	7.60	— .50	Y. C.
Pepeekeo Sugar Company	5	7.72	7.94	6.45	6.52	— .07	Y. C.
Hakalau Plantation Co.	17	8.34	8.24	5.59	5.62	— .03	Y. T.
Totals		47.27	43.81	34.63	35.14		
Averages		9.45	8.76	6.93	7.03	— .10	
Kaiwiki Sugar Company	1	7.44	7.22	5.65	5.67	— .02	Y. C.
"	4	7.63	7.26	3.21	3.39	— .18	Y. C.
Hamakua Mill Company	1	7.90	7.75	1.93	1.98	— .05	D 1135
Paauhau Sugar Plt. Co.	10	8.30	8.20	5.62	5.57	+ .05	D 1135
Niulii Mill & Plt. Co.	1	8.65	8.43	1.92	1.80	+ .12	Y. C.
Union Mill Company	21	7.88	7.53	6.45	6.20	+ .25	Striped Tip
Hawi Mill & Plt. Co.	2	7.88	7.93	6.86	6.59	+ .27	D 1135
Totals		55.68	54.32	31.64	31.20		
Averages		7.95	7.76	4.52	4.46	+ .06	
Kilauea Sugar Plt. Co.	7	8.55	8.54	3.73	3.69	+ .04	Y. C.
"	4	8.80	8.68	3.09	2.94	+ 15	Y. C.
Lihue Plantation Co.	11	12.40	12.30	3.70	3.60	+ .10	Y. C.
Grove Farm Co., Ltd.	8	8.43	8.41	4.84	4.98	— .14	Y. C.
Koloa Sugar Company	20	12.38	11.20	3.09	3.00	+ .09	Y. T.
"	30	11.55	11.45	4.91	4.67	+ .24	Y. T.
Totals		62.11	60.58	23.36	22.88		
Averages		10.35	10.10	3.89	3.81		
Wailuku Sugar Company	1	6.97	6.66	12.40	12.18	+ .22	Lahaina
Oahu Sugar Company	8	9.66	9.24	8.45	7.96	+ .49	Lahaina
"	17	11.18	11.06	6.03	6.11	— .08	D 1135
Totals		27.81	26.96	26.88	26.25		
Averages		9.27	8.99	8.96	8.75	+ .21	
Grand Total and Averages.		192.87	185.67	116.51	115.47		
		9.21	8.85	5.55	5.50	+ .05	

J. A. V.

The Bindweed

By E. L. Caum

The California bindweed or morning-glory (*Convolvulus arvensis* Linn.) was first recorded from Hawaii in 1918, when plants were found on Maui and Oahu. Recently, the weed has come to the fore as a possible cane-field pest, and questions as to identification and methods of eradication have arisen.

Although by its common name accredited to California, the plant is probably a native of Europe, and is widely distributed throughout the temperate and subtropical regions of the world. California, however, is undoubtedly the immediate source of the weed in Hawaii, the seeds arriving thence in baled hay or stock feed of some kind. The bindweed is a vine, spreading chiefly by means of the long, creeping, cord-like roots, which may bud new plants at any part of their length. The stems are smooth, slender, twining and leafy, attaining a length of about three feet. The leaves range in length from one to three inches, and are shaped more or less like an arrow-head or spear-head, with two lobes at the base. The leaves vary considerably in shape, even on the same stem, ranging from obovate-hastate to broadly and bluntly triangular, and in some instances the basal lobes are not clearly differentiated. Somewhere on the plant, however, will be found leaves that plainly show the characteristic ear-like tabs. Fig. 1 shows the range of variation in leaf shape exhibited by this weed. The basal lobes will serve to distinguish the plant immediately from any of the other morning-glories that may occur in or along the edges of the cane fields, as these others all have leaves that are either clearly heart-shaped or digitate. The flowers are funnel-shaped, one inch or somewhat less in length and diameter, white or pinkish, occurring singly or in pairs, but occasionally three or four in a cluster. The small, roundish seed-pods are two- to four-seeded. The seeds are dull dark brown, coarsely roughened, oval, 3 to 4 mm. or about 1/6 of an inch long, one face convex, the other face sloping to the edges from a broad central ridge.

This European bindweed, together with the American species *C. sepium,* which thus far has not been reported from Hawaii, are most obnoxious weeds, in many parts of the country ranking among the worst of all the agricultural weed pests, and in some regions they are by far the worst. *Convolvulus arvensis,* fortunately the only one with which we are now concerned, is so destructive of crop plants when it occurs in cultivated fields and so difficult of eradication when it once becomes established that every effort should be made to extirpate the species before it becomes widely distributed throughout the agricultural lands of the Territory.

The outstanding injurious effects caused by the weed are: (1) It reduces crop yields. By growing with crop plants, the bindweed is in direct competition with them, and occupies space that is intended for the crop. The roots rob the crop plant of food and water while the stems, twining about and over any plant within reach, rob it of light and air. Under these conditions it is obvious that

Fig. 1. Variation in the leaves of the Bindweed, drawn natural size from Hawaiian specimens.

reductions in crop yields are bound to result. Small plants such as vegetables cannot compete with the weed, and are soon completely choked out. Larger and taller plants such as corn, and by inference cane, can grow away from the weed if they are given a fair start, but otherwise they too will be dragged down and smothered by the rank growth of the vine, unless expensive and continuous hand cultivation is practiced. The ordinary machine cultivators are absolutely useless for keeping the bindweed in check. Corn fields where the weed is luxuriant, and where only the normal weed cultivation is given, will often show a complete loss. Even where the crop plant gets above the vine, there is still the loss of water and nutrients to be considered. With the continuous growing season that we have in Hawaii, it is easy to see that the weed might well do serious damage to young cane.

(2) It increases the amount of labor and the cost of field operations. Crop losses may be reduced by thorough tillage, and the reduction in crop thus partially

overcome by the greater amount of cultivation given. This, of course, increases the cost of the crop two ways, a greater cultivation cost for a smaller yield. In still another way the weed increases costs, since by twining around and over the crop plants it makes a dense tangle along the ground, increasing the labor involved in harvesting.

(3) It is a menace to near-by uninfected areas. This point is obvious, as the plant cannot be kept within bounds by ordinary methods, and each small patch is a center of infection for the surrounding territory.

(4) It reduces land values. This is a natural corollary of the points brought out above, and was strikingly illustrated a few years ago in Washington when, even during the time of high land values, individuals and companies engaged in selling and loaning money on land were glad to sell bindweed-infested fields for what they could get, and they refused to make any loans at all on such fields. One such individual made the statement that "If in bodies of from one to five acres, I would not consider the acreage covered of any value, as the cost to eliminate would be more than the worth of the land."

The bindweed is most difficult of eradication, and in this connection the following quotation, taken from Bulletin 42 (1899) of the Iowa Agricultural Experiment Station, may be of interest:

> Tempted by the lively appearance which I had often observed some banks to assume from being covered with the blossoms of this Convolvulus, I planted twelve feet of a bank in my garden, which was about four feet in height, with some roots of it; it was early in the spring and the season was remarkably dry, so that I scarcely expected to see them grow; but a wet season coming on, soon convinced me that my apprehensions were unnecessary, for they quickly covered the whole surface of the bank, to the almost total extirpation of every other plant. It being a generally received opinion, that if a plant was cut down close to the ground, it could thereby be destroyed, or at least, very much weakened, I was determined to try the validity of this opinion by an experiment, and accordingly, the whole of the Convolvulus was cut down somewhat below the surface of the ground. In about a month the bank was covered thicker than before. I then had recourse to a second cutting, and afterwards to a third; but all these were insufficient; for now at this present writing (August) the bank is wholly covered with it; nor do I expect to destroy it, but by leveling the bank and destroying the roots.

The bindweed spreads in three ways, by seeds, by lateral spreading, and by the transfer of root parts. The first of these methods, seed, is probably the least important, although this was undoubtedly the means by which the plant reached Hawaii. Under local conditions at least the plant seems to flower rather rarely and sparingly, although the vegetative growth is luxuriant. Such seeds as may mature can easily be carried to new areas embedded in mud adhering to the shoes of a person walking through a bindweed patch. The greatest danger in seed dispersal, however, is where the plant is permitted to grow along the banks of streams or irrigation ditches, where the water can easily distribute the seeds far and wide. The other two methods of distribution, lateral spreading and transfer of root parts, come about as a result of the great extent and the almost incredible vitality of the root system. The main roots, long and cord-like in character, penetrate the soil in all directions and to a great depth, frequently more than six feet. These roots,

particularly the uppermost portions near the surface, bear buds which send up new shoots, or adventitious buds may form at any part of their length, to give rise to either roots or shoots. For this reason a simple grubbing out of the plant is entirely insufficient, as the pieces of root left in the soil will form buds and give rise to new plants. Harrows, plows and similar machine cultivators are rather efficient distributors of the weed, as in passing through a bindweed patch they will break off pieces of the main roots which, in being dragged over and dropped in uninfested areas, will start growth and produce both roots and shoots, and thereby form new centers of infestation.

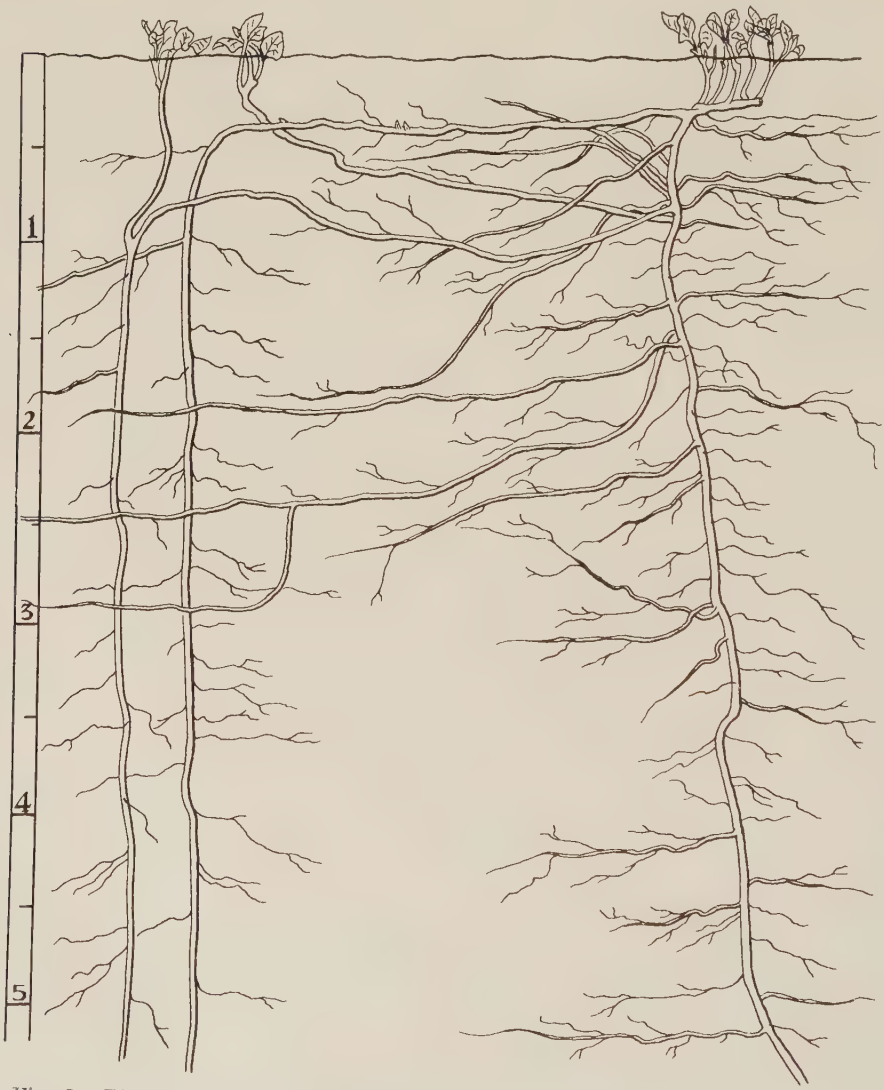

Fig. 2. The root system and budding habits of the Bindweed (after Schafer). The scale at the left is marked in feet.

Many methods of control of this weed pest have been tried, but very few have proven successful, and none of them is both cheap and speedy. Where it is feasible, one method that has been used with a measure of success is turning hogs into infested areas, after one or two thorough plowings to loosen the soil and bring the roots to the surface. These animals are very fond of both the tops and roots of the bindweed, and will in time eliminate it, if aided by an occasional plowing. Another method is to plant infested areas to alfalfa. This crop, if it can be well established before the weed gets too heavy, seems to resist the development of the bindweed, and the frequent cutting of the alfalfa or the utilization of the alfalfa patch for pasturage will keep the bindweed from seeding and will eventually starve it out. This, as may be judged, is a matter of years, although the weed is in no way injurious to animals, and has no detrimental effect on them when mixed with their fodder. The most successful way of eliminating the bindweed, however, and the one requiring the most care and attention, is clean cultivation, but this cultivation must be thorough and persistent. Hand hoeing that is not thorough and not sufficiently frequent will simply aggravate the trouble. If the top growth is kept continually cut off, no seeds can form and the roots will in time be starved out. To employ another quotation, "Nothing but persistent watching and the careful cutting off of all parts above the ground will eradicate this weed." Of course, in the absence of experiments along these lines in Hawaii, it is impossible to say how long a process this may be, but on the mainland it is said that going over the land once every week or ten days, during the entire growing season of the weed, which is between the spring and fall frosts, is required, and this treatment should accomplish the desired results in two years in most cases, and probably one year would suffice if the plants were not deeply rooted. By a year is meant a growing year, of course, not a calendar year, and Hawaii's twelve-month growing season, with the roots working steadily to produce top growth, should bring about their final exhaustion much sooner.

This practice of clean cultivation with hand implements is recommended primarily for areas of infestation in cultivated ground, where the fertility of the soil is of importance and must be preserved. The same effect, a continuous killing of the top growth, can be achieved by the use of a standard arsenical spray, but the sprayings must be frequent enough to knock down the green tops of the weed as soon as they appear. There is some danger in the use of this spray, however, as arsenic is known to have a stimulating effect on plant roots, and while it is satisfactory for use on succulent weeds where the death of the tops is followed quickly by the death of the roots, the results might be very different in the case of a weed with a root system as tenacious of life as is that of the bindweed. Various other chemical herbicides have been employed in experimental work, but most of those that are sufficiently strong to kill the weed have the disadvantage of either poisoning the soil or of being expensive, or both. Common salt is effective, but it must be applied at the rate of about one pound per square foot, and it has detrimental effects on the soil. Sodium chlorate in a 12.5 per cent solution was used successfully in Kansas, three treatments about two to three weeks apart being sufficient to eradicate the weed, but the after effects of the chemical are uncertain.

In the Kansas experiments it was claimed that there were no soil poisoning effects, but some experiments in Hawaii have shown a very decided adverse effect on cane growth, while other experiments have shown no noticeable effect at all. It might be dangerous to use sodium chlorate in fields of growing cane.

Naturally, the most efficient herbicides are the ones that destroy the roots of the weed, not limiting their action to simply burning off the top growth, and these are exactly the herbicides that cannot be used close to growing crops. They can, however, be used in fallowed fields prior to planting, or in places where the

Fig. 3. The California Morning-glory or Bindweed, showing habit of growth (after Criddle).

preservation of the soil fertility is of no importance. An effective spray of this sort is an emulsion of one part of Diesel oil with two parts of water, which is more effective than the Diesel oil alone. With many kinds of weeds this emulsion not only kills the tops but very quickly rots out the roots, and although we know of no experiments made with it on the bindweed, it has proven deadly to many other perennial weeds, and it has no residual effects. Along railroad tracks, in roadways and similar situations a half-and-half mixture of crude oil and kerosene may be used. It was this mixture that was used to wipe out the weed along the railroad right-of-way on Maui at the time of its first appearance in 1918. Other herbicides that act quickly and surely are carbon bisulphide and chloropicrin, but both of these are expensive, and the cost of application on large areas might be rather high. Chloropicrin in particular is certain death to any plant with which it comes in contact, has no poisoning effects on the soil, and could well be applied despite its cost should the Diesel oil emulsion prove ineffective. It is an open question whether high priced materials of this sort would really be high priced in the end. There is no doubt but that a single good application of chloropicrin will eradicate the weed, and the failure to eradicate it, followed by its establishment in the fields, would also prove expensive, as would continuous hand hoeing over a period of possibly a year. However, in dealing with an incipient weed pest having the potentialities of the bindweed there should be no false economy practiced.

To summarize: The California morning-glory or bindweed is known to have been in Hawaii for about fifteen years, and although in other places it is an agricultural pest of major importance, in Hawaii it has not as yet assumed that position. Judging by the losses caused by it in other parts of the country, its potentialities for damage to the agricultural industries of Hawaii are great. It is most tenacious of life and extremely difficult to eradicate. There is no proven method that is both cheap and speedy. An emulsion of one part of Diesel oil to two parts of water is highly effective when used on other perennial weeds, and has no detrimental effects on soil fertility. There seems to be no good reason why it should not prove equally effective on the bindweed. Failing this, chloropicrin is a swift and certain plant poison with no soil poisoning features, but it is expensive. If neither of these methods of eradication are feasible, the only other safe method is clean culture by thorough hand hoeing at intervals of a week or ten days, or as often as necessary to prevent the formation of top growth. Most herbicidal sprays are no more efficient than this hand hoeing, and some are less so. Where the preservation of the soil fertility is of no consequence, a half-and-half mixture of crude oil and kerosene has been shown to be effective.

A brief illustrated note on the occurrence and habits of the bindweed was published in the *Hawaiian Planter's Record,* Vol. XIX (1918), pp. 347-349, and more recently an illustrated discussion of the weed appeared in *Weeds of the Pineapple Fields of the Hawaiian Islands,* by St. John and Hosaka (*University of Hawaii Research Publication No. 6,* 1932), pp. 122-123.

Chromosomes of Sugar Cane

Translated literally the word chromosome means "color body." The term is appropriate because these small bodies are deeply stained when treated with certain dyes.

As everyone knows, each living cell, whether plant or animal, contains a nucleus, a more or less spherical mass of protoplasm which is denser than the surrounding material in the cell. During its resting stages this nucleus tends to have the appearance of a homogeneous mass. When the cell is making ready to divide, however, part of the nuclear material resolves itself into a number of small units of protoplasm. These are the chromosomes.

The number of chromosomes is definite and constant for each species. The chromosomes of many species of plants and of animals have been investigated by cytologists during recent years. The following list gives a few examples of the numbers found.

	Pairs of Chromosomes
Garden pea	7
Garden bean	8
Wheat	21
Tobacco	24
Dog	11
Cat	18
Man	24

It may be asked why we speak of "pairs" of chromosomes. The reason is obvious if we remember that each new individual results from the union of an egg cell formed by the mother and a spermatozoan (or pollen nucleus) supplied by the father. One member of each pair of chromosomes, then, is contributed by the mother and the other member of each pair by the father.

The chromosomes are believed to be the carriers of the "factors," or "genes," which determine heredity. Sugar cane seedlings, to cite a familiar case, differ from each other in many respects. Some are slender like Uba, others thick like Caledonia. Some are red like D 1135, others are yellow like Lahaina. Some are high in sucrose like Badila, others low like Kassoer. How do these differences come about? The present conception of the mechanism of heredity is that the traits of each individual are determined by the action and interaction of these "genes," or "factors," carried by the chromosomes.

The chromosome number in man, as has already been mentioned, is 24 pairs. Each living cell in the human body contains a nucleus, and each nucleus contains its 24 pairs of chromosomes.

When a cell divides to form two new cells each chromosome splits lengthwise with the result that each of the two new daughter cells receives its full complement of 24 pairs of chromosomes.

Fig. 1. Photomicrograph of the male and female organs of an H 109 cane flower. The male organs are comprised of three stamens with their reddish anthers, containing bags of yellow pollen. The female organ is comprised of the pistil with its two feathery purple stigmas and white ovary.

One might reasonably ask why it is that the human embryo resulting from the union of an egg cell and a spermatozoan does not contain twice as many chromosomes as either parent. In other words, if each cell in the bodies of both the father and the mother contains a nucleus composed of 24 pairs of chromosomes, is it not to be expected that the new individual resulting from a fusion of the male nucleus and female nucleus would have 48 pairs?

The explanation is simple and at the same time remarkable. As we have already seen, when an ordinary body cell divides to form two new cells, each chromosome splits lengthwise, and each daughter cell thus contains exactly as many chromosomes as the cell from which it was formed. However, when a cell in the ovary of the female or the testicle of the male divides to form an egg cell or a spermatozoan the chromosomes do not split lengthwise. Instead the two members of each pair of chromosomes part company and the resulting germ cell thus contains only one chromosome of each pair. This process, which results in reducing the number of chromosomes from 24 pairs in the body cells to 24 single chromosomes in the germ cells, is called the "reduction division." This mechanism of germ cell formation prevails throughout the plant and animal kingdoms.

The reduction division provides an opportunity for the reshuffling of chromosome combinations. Thus in man, some spermatozoa will be formed which contain all 24 of the chromosomes which the individual received from his father, and, consequently, none of those which he received from his mother. Other spermatozoa will contain 23 of the paternal and only one of the maternal chromosomes, still others 22 and 2, and so on. As a result, the individual produces many types of spermatozoa, some of which carry a preponderance of the chromosomes which he received from his father, others a preponderance of the chromosomes which he received from his mother, and still others in which the honors are equally divided.

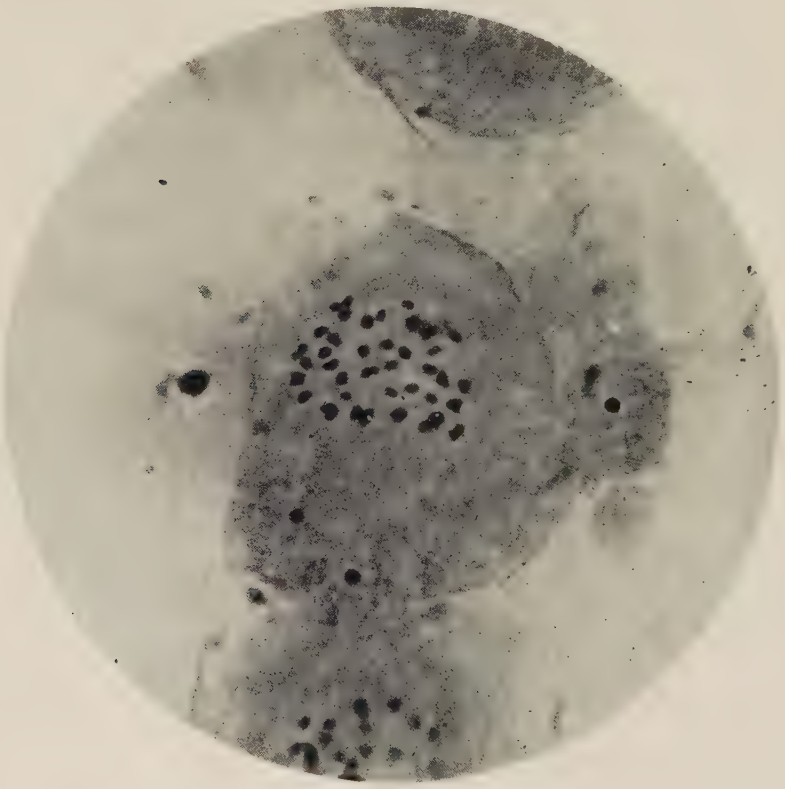

Fig. 2. Photomicrograph of chromosomes of H 109 cane. They are shown here in one of the cells found within the anther of the cane flower, which cell by dividing twice forms four pollen grains. In the nucleus of these cells, called "pollen mother cells" (microsporocytes), occur 40 pairs of chromosomes, and it is here that the so-called "reduction division" occurs, i.e., when these cells divide, one of each of the pairs of chromosomes is distributed to each of the two daughter cells. Thus, in pollen grains there are found only 40 chromosomes, while 80 are found in the vegetative cells of the plant, i.e., those cells found in the root tips, leaves, stalks, etc. × 1577.

For many years, Bremer (1, 2, 3, 4, 5, 6), the cytologist at the Pasoeroean Station, in Java, has been studying the chromosome relationships in the various species of sugar cane. He finds that the thick or "noble" canes, of which Lahaina is a typical example, have 40 pairs of chromosomes. The Uba group has 59 pairs, and the wild *Saccharum spontaneum* has 56 pairs.

Bremer reports an unusual phenomenon when the noble canes are pollinated by the wild *spontaneum* canes. The nucleus of the egg cell of a noble cane contains 40 chromosomes. The nucleus of the pollen grain of *spontaneum* contains 56 chromosomes. One would expect that when the two nuclei unite the resulting embryo would have 40 + 56 or 96 chromosomes. Actually the hybrids between the two species which Bremer has studied have 136 chromosomes.

Fig. 3. The chromosomes of H 109 cane shown diagramatically. This drawing was made to scale by the aid of a camera lucida and shows the same cell as is pictured in Fig. 2. By the use of such drawings the chromosomes may be counted with less difficulty. × 2760.

Bremer advances the following explanation: When the egg nucleus of a noble cane unites with the pollen nucleus of a *spontaneum,* the chromosomes of the former are stimulated in such a way that they divide prematurely, so that instead of 40, the egg nucleus now contains 80 chromosomes. This nucleus, when it fuses with the pollen nucleus, produces an embryo which contains 80 + 56 or 136 chromosomes, the number actually observed.

As a result of the doubling of the chromosome number in the egg cell of the noble cane mother, the hybrid seedlings might be expected to show more of the noble cane characteristics and less of the *spontaneum* characteristics than would otherwise be the case. It is interesting that the hybrids between the two species do in fact bear a closer resemblance in stature to their noble cane mother than to their *spontaneum* father.

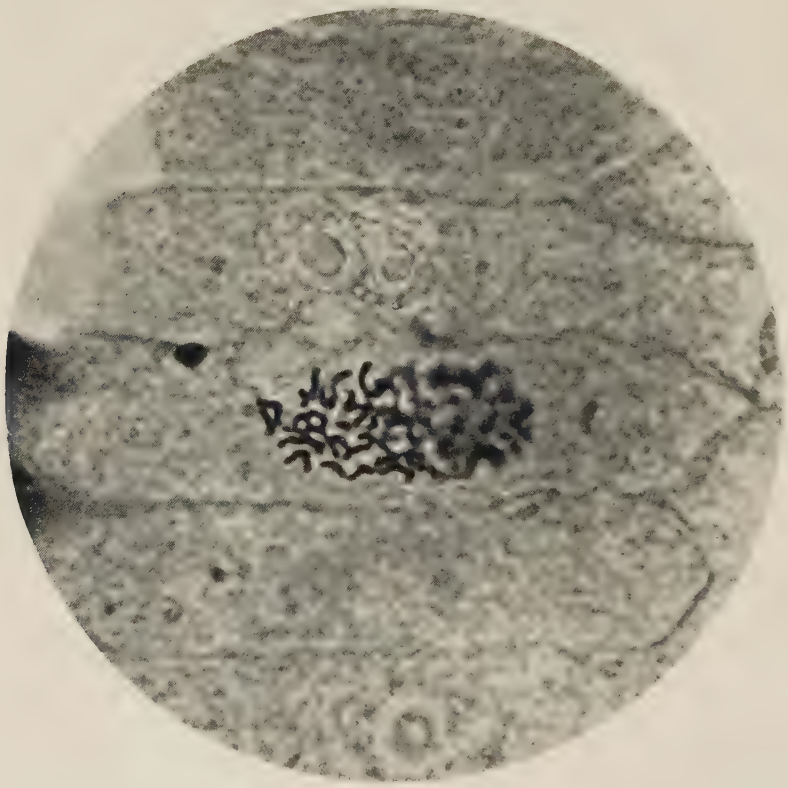

Fig. 4. Photomicrograph of chromosomes of H 109 cane. They are shown here in a cell of a root tip and are 80 in number, or just twice the number found in the pollen grains and egg cells in the flowers. In such vegetative cells the chromosomes are characterized by being the shape of small bent rods somewhat entwined together, while in the pollen mother cells they are shorter and thicker, being almost isodiametric clumps. × 2103.

The results of this finding of Bremer's may be cited as an example of the sort of information which cytological studies may bring to bear on breeding problems.

There is much still to be done in this field. Cytological work is exacting and time-consuming and progress is necessarily slow. It is to be hoped, however, that in the course of time our information on the chromosome relationships in the various cane species and their hybrids will be more complete than it is today.

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* These three citations are translated in Genetica, Vols. V, VI, VII, respectively.

D. M. W.
A. J. M.

Measuring Production in Terms of Temperature

By U. K. Das

It is generally admitted that the high level of production in these Islands is due to the application of scientific methods in our cane culture.

These methods consist of precise measurement and control of our resources and of the essential factors in production. We measure our land, we measure the amounts of seed and fertilizer that go into this land, we measure the man-days of work required to bring a crop to maturity, we measure the amount of water applied, and recently we have also begun to measure the factor of time as is evidenced by the increasing use of such terms as yields per acre per month.* But there are other essential factors in crop production besides soil, fertilizer, labor, water and time, namely, temperature and sunlight. It is, therefore, the logical sequence of the increasing application of science in our cane production that we should now turn our attention to measurement of temperature as an aid to future progress.

Temperature and Cane Growth

Before we proceed further let us see what we know about the effect of temperature on cane growth. Alexander (1), Stender (2), and others have shown by actual field measurements of cane growth that under conditions of abundant plant food and moisture the relation between temperature and cane growth is very marked indeed. (A figure from Stender's work is reproduced here below.) If the relationship is so pronounced, may it not be worth while to make an attempt to devise some means by which we can measure this temperature effect much the same as we would measure, let us say, the effect of irrigation water applied?

Measurement of Temperature Effects

It was De Candolle, the famous botanist, who pointed out many years ago that below a certain temperature plants could not grow and that effective warmth must be reckoned as "accumulated temperature" above this minimum point. At the instance of Sir John Lawes and Sir Henry Gilbert, of Rothamsted, the British meteorological authorities began to issue their statistics of warmth in relation to agriculture as accumulated temperature.

This accumulated temperature is obtained by taking the effective temperatures above the selected zero point and summing them up for the number of days a crop has been in the field.

* The Experiment Station, H. S. P. A., drew attention to the value of this "per acre per month" conception. (Annual Report, Experiment Station, H. S. P. A., 1918, p. 7.)

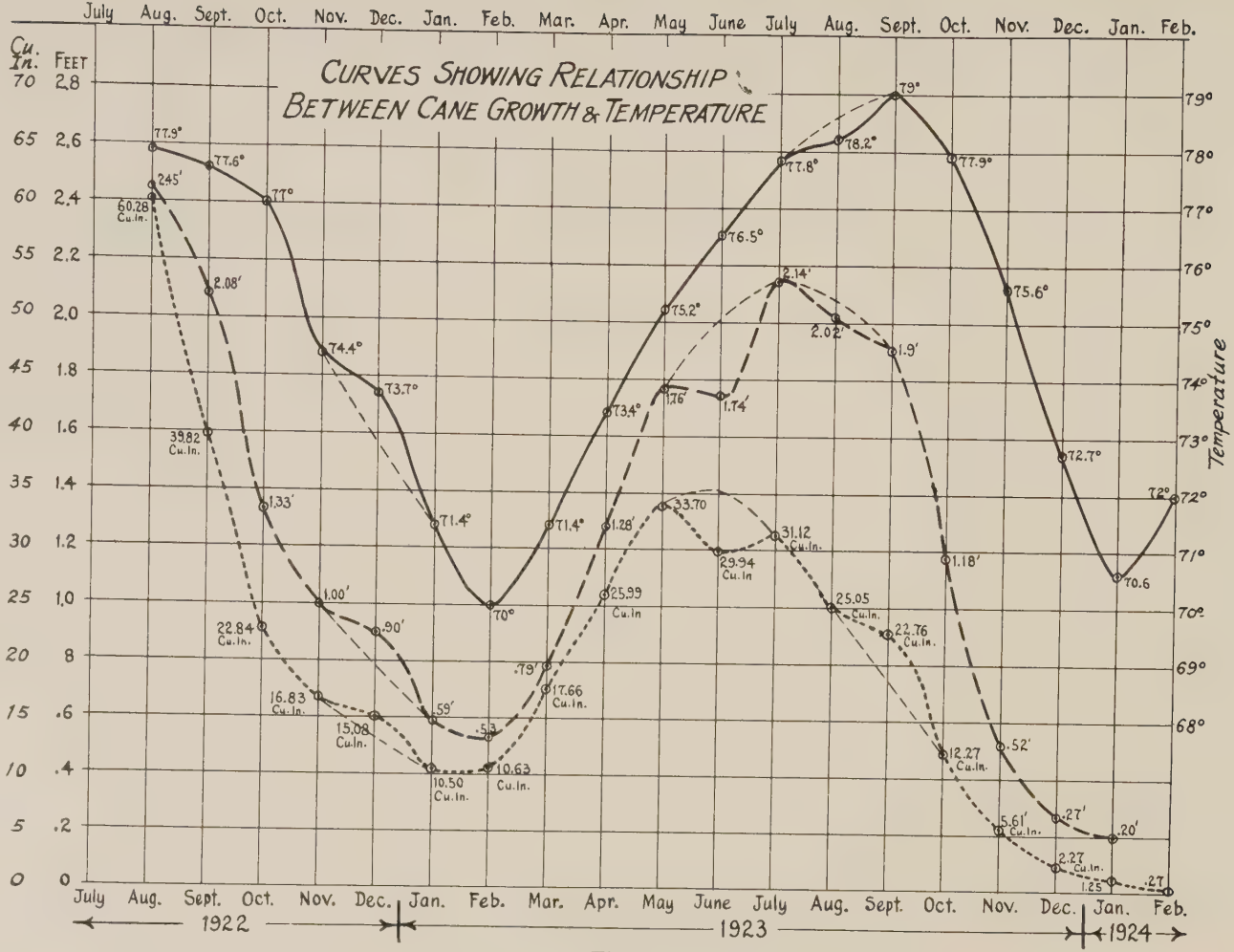
CURVES SHOWING RELATIONSHIP BETWEEN CANE GROWTH & TEMPERATURE
Cu. In.
Feet
Temperature
July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb.
1922
1923
1924
77.9°
77.6°
77°
74.4°
73.7°
71.4°
70°
71.4°
73.4°
75.2°
76.5°
77.8°
78.2°
79°
77.9°
75.6°
72.7°
70.6°
72°
60.28 Cu.In.
2.45'
2.08'
39.82 Cu.In.
1.33'
1.00'
.90'
22.84 Cu.In.
16.83 Cu.In.
15.08 Cu.In.
.59'
.53'
10.50 Cu.In.
10.63 Cu.In.
.79'
17.66 Cu.In.
1.28'
25.99 Cu.In
1.76'
1.74'
33.70
29.94 Cu.In
2.14'
2.02'
1.9'
31.12 Cu.In.
25.05 Cu.In.
22.76 Cu.In.
1.18'
12.27 Cu.In.
.52'
5.61' Cu.In.
.27'
.20'
2.27 Cu.In.
1.25
.27

Fig. 1

Smith (3) states that besides this process of summing up temperature, known as the "remainder" indices, there are two other methods known respectively as "the exponential" and the "physiological summation" indices.* We shall not go into a detailed discussion of the relative merits of all these processes; suffice to say that they all have their good and weak points and none of them alone can explain all the facts concerning the growth and yield of a crop.

Zero Point of Cane Growth

Most of the work with the summation processes has been done on subtropical crops and 42° F. has been usually taken as the zero point. But sugar cane is of tropical habitat and we know that it hardly makes any growth in winter in Louisiana or in the Punjab, India, where the mean winter temperature is about 55° F. We also know from actual measurements of cane growth as reported by Stender (2), Verret and Das (4), and others, that cane growth falls off very rapidly and becomes negligible below a mean temperature of 65°. From these considerations we feel justified in taking 60° F. as our zero point. In this we are not alone. Kincer (5) suggested that this zero point should be 55° F. for corn and 60-62° F. for cotton. Very recently Magoon and Culpepper (6) have published a detailed investigation into the zero point of effective temperature for corn, and these authors have come to the conclusion that this varies between 50 to 65°, depending on the variety of corn. (We may also find the zero point to be different in the different varieties of cane. Not enough data are available at present to test this point.)

* The exponential indices are based on the application of Van't Hoff's Law—namely, the velocity of chemical reaction is doubled with every 18° F. rise of temperature. The physiological summation indices are similar to those suggested by Livingston (14) from a study of the data obtained by Lehenbauer with maize seedlings. The indices are derived from actual length growth recorded at different temperatures.

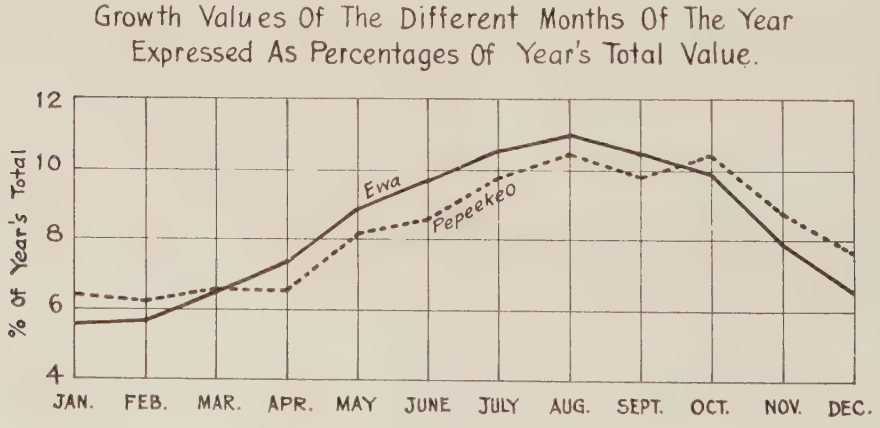

Fig. 2

Mean or Maximum Temperature as the Zero Point

The mean temperature is usually taken as the zero point. As we know, this mean temperature is obtained for each day by adding together and then dividing by two the maximum and the minimum temperature. Two places can have widely differing maximum and minimum temperatures yet they may have the same mean temperature. Thus a mean temperature of 70° F. may be obtained from a maximum of 80° F. and a minimum of 60° F. or a maximum of 100° F. and a minimum of 40° F.

Now, mean maximum temperature is usually an index of conditions by day and mean minimum of conditions by night. We also know that distinct life processes are carried on by a plant during the daylight hours and during the night. Surely, then, two places having the same mean but widely differing maximum and minimum temperature will not exert the same influence on plant growth. It is, therefore, evident that use of mean temperature may be wholly unsatisfactory as a base for obtaining total warmth or accumulated degrees, especially so when the resulting information is to be used for comparing one locality with another.* There is another good reason why we should prefer to use maximum temperature instead of the mean temperature. Seeley (7) has shown that what effects plant growth is not the air temperature but the actual leaf temperature, which is considerably modified by the conditions of the day—sunshine, clouds, etc. Maximum temperature may, therefore, be a closer approximation to plant temperature than the mean.

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* To illustrate the point—Waimanalo (Oahu) has an annual average maximum temperature of 81.7 and an annual minimum of 68.9°. Adding the two figures, and dividing by two we get 75.3° as the annual mean temperature of Waimanalo. The annual maximum for Ewa, Waipahu, and Waialua, is 83°, 82.5°, and 82.6°, and the minimum 64.6°, 65.9°, and 63.7°, respectively. The mean temperatures of these places are then 73.8°, 74.2°, and 73.2°. Taking mean temperatures only we would say that Waimanalo has the best temperature climate. But all of us know that cane does not yield as well in Waimanalo as in the other three places mentioned. In fact, from physiological considerations we would expect Ewa and the other two places to be more favorably placed. For it has been recorded with other crops that, at least in the case of the adult plant, assimilation of dry matter (sugar in our case) is favorably influenced by a high day temperature and a comparatively low night temperature. High day temperature (an index of which is maximum temperature) favors assimilation rate while low night temperature (an index of which is minimum temperature) prevents excessive loss by respiration. Lundegardh (9) has shown that with equal day temperature a raising of night temperature by 10° C. causes an increase in loss by respiration of as high as 30 per cent of dry matter in a field of potatoes. The presence of this positive correlation of yield with maximum temperature and negative correlation with minimum temperature was actually demonstrated in a previous statistical study (10) of the Ewa Plantation Company.

It must, however, be added that as long as the study and the information obtained are confined to one plantation only, mean temperature may provide just as good a zero point as the maximum temperature. In fact our previous study (11) of the Pepeekeo Sugar Company has shown that mean temperature provides a satisfactory base for calculating total warmth.

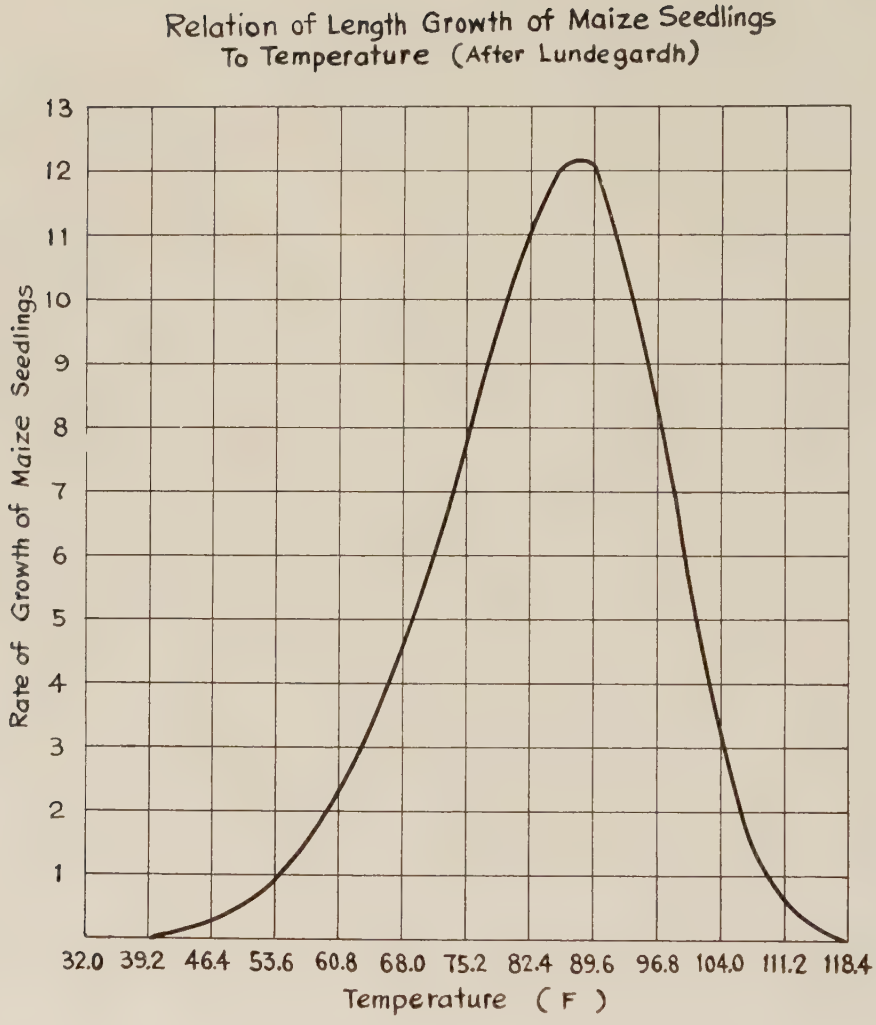

Fig. 3

Day Degrees—or Effective Temperature for Cane Growth

If 60° F. of mean temperature should be the zero point of cane growth, as argued previously in this report, what should it be in terms of maximum temperature? The plantation weather stations of these Islands show a difference of 14 to 20° between the average minimum and the average maximum temperature. By taking half of this difference and adding to the zero point of mean temperature we get our new zero point of maximum temperature which is 67° to 70°. For the sake of simplicity we shall take 70° F. of average maximum temperature as the new zero point. A day-degree will then be defined as one 1° F. above 70° of maximum temperature for one day. To obtain the total or accumulated day degrees for one month, we may either add the day degrees for each

day or we may simply multiply the average maximum temperature of the month by the number of days in the month.*

Growth Values of Different Months in Terms of Effective Temperature

Several years ago Agee (8) called our attention to the advantage and necessity of evaluating the growing powers of different months of the year. From cane growth data and from considerations primarily of the hours of daylight, he derived growth values for each month of the year. In the case of Honolulu, the month of July was found to have anywhere from 3 to 5 times as much value as the month of January or February.

Let us now deduce these values from considerations of temperature alone. In Table I we take the temperature data of the Ewa Plantation Company and calculate the day-degrees normally received from month to month (normal temperature is the average of 26 years of data—from 1905 to 1931). Assuming the yearly total of day-degrees to be 100, we now calculate the percentage of day-degrees in each month of the year. Table I shows that at Ewa, 11 per cent of the year's total of day-degrees is in the month of August and only 5.6 per cent in January. In other words, if cane growth was proportionally influenced by temperature in the two months, we should expect to find twice as much growth in August as in January. The earlier work of Alexander (1) and more recent work do actually show that this ratio of 2 to 1 between August and January growth at Ewa is not far from the truth.

Similar values are worked out in Table I, for Pepeekeo Sugar Company. The monthly values for both Ewa and Pepeekeo as shown in Fig. 2, bring out interesting differences between the two places. From temperature standpoint, the fall months of Pepeekeo appear to be more important than those at Ewa, while in the latter case the spring months are the more important. This fact should deserve some consideration in the agricultural practices of the two places.

Differential Effects of Temperature at Higher Ranges

In the foregoing calculation, we have assumed that one degree of temperature between 70° F. and 71° F. is as effective as one degree between 80° F. and 81° F. This is contrary to the experience of plant physiologists, who find that temperature effects are different in the different ranges. How complex these effects are will be seen in the following graph (Fig. 3), reproduced from an article by Blackman (13). It shows the rate of length growth in maize seedlings at various temperature levels. We see that the rate of growth between 60° and 70°, for instance, is not the same as between 70° and 80° or 80° and 90°. There is no single law

* After the temperature has passed beyond a certain point, it may be harmful to growth rather than helpful. This maximum point varies with the kind of plant and to a certain extent with other environmental factors. In the case of sugar cane we have reasons to believe that the maximum point is seldom, if ever, reached in the plantations of these islands. The highest average maximum temperature for a month recorded in any of the plantation is 90° F. Louisiana exceeds this temperature in the summer months and we know that in Louisiana it is the summer months that produce growth. The average maximum temperature for the spring and winter months of Pasoeroean (Java) is 89° F. and Pasoeroean is one of the most productive sugar cane regions in Java.

or a simple formula that can completely describe this differential growth rate, which varies not only with temperature, but also with the kind of plant, or the kind of function of the plant. It is known, however, that the Van't Hoff principle—the velocity of reaction doubles itself with every 18° F. rise of temperature—applies to plant growth to a limited extent.* Assuming this law to be valid within the rather narrow range of seasonal differences in temperature obtained in these Islands, we may recalculate the growth values of the different months at Ewa. (See Technical Appendix—A.)

The new values are shown in Table II and Fig. 4. In comparing these new values with those given in Table I, we note that August has increased in value from 11 per cent to 12.1 per cent of the year's total, and January has decreased from 5.6 per cent to 4.7 per cent. For comparison, some values suggested by Agee (8) are also given in Table II. There is a surprising agreement between these values and the values originally obtained by Agee from consideration of daylight hours. But, whereas Agee's data would place the highest value on the month of July, the new curve shows August to have the highest value under Ewa conditions. Actual growth measurements taken in Honolulu do indeed show that under normal conditions we obtain more growth in August than in any other month of the year.

Growth Values of Different Months—Their Relation to Crop Cycles

The fact that no two months are alike in their capacity to produce growth is one that must be reckoned with in our crop schedules and agricultural practice. Agee (8) has pointed out in his original paper that, depending on the season of starting, a crop 18 months old may actually produce as much as one 20 or 22 months old.

* Lundegardh (9) states that the Van't Hoff law applies to plant growth only within a very limited range.

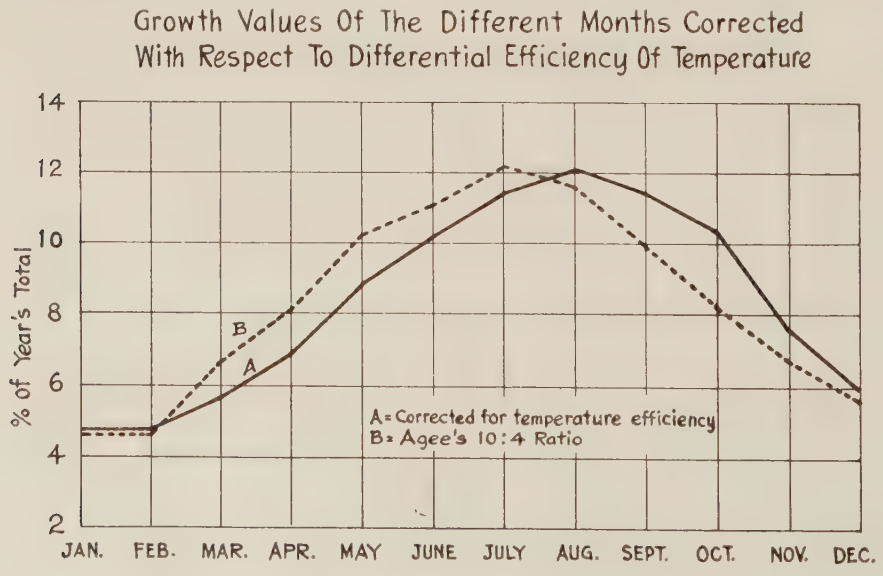

Fig. 4

Without going into a detailed discussion of the bearing of these different growth values on our cropping scheme, we may submit that most economic use of time and resources can only be made by taking into account the existence of such well established differences.

Accumulated Day Degrees (Total Warmth) and Yield

Having shown the usefulness of this conception of day-degrees to the evaluation of the growth values of the different months of the year, we may now proceed to evaluate yield in terms of actual warmth received. To start with let us take the comparatively simple case of the Pepeekeo Sugar Company. Here we have yield data for the past 22 years comparatively little affected by changes of cane variety, soil, crop length or management. These yield data should, therefore, provide a test for the applicability of day-degrees to crop performance.

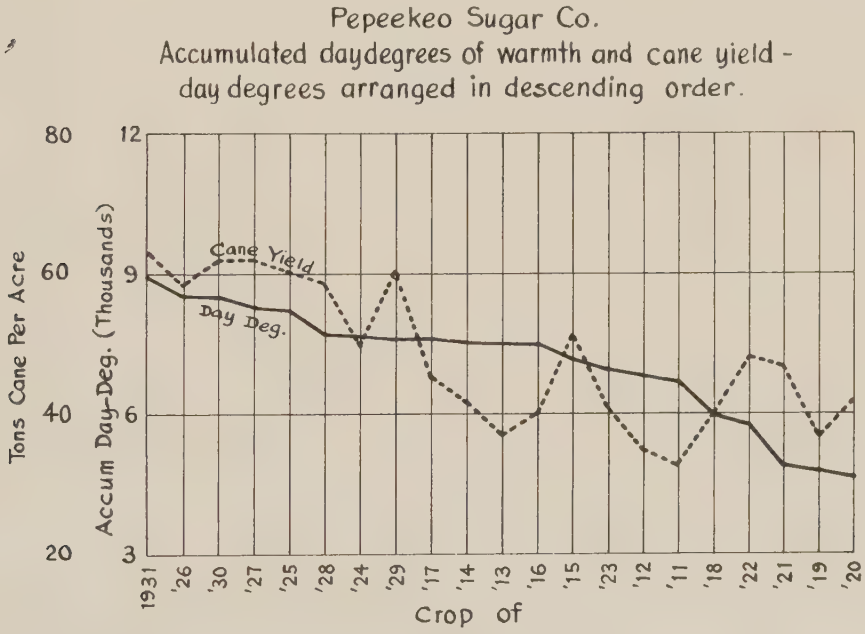

Fig. 5

At Pepeekeo long cropping has been and still is the general rule. We may then assume, for the sake of simplicity, a crop length of 24 months. We may also assume that July 1 is the average date of starting, that is by July 1, about half the area has been started. Now, from records of temperature, we may calculate for each of the past crops the total warmth or accumulated day-degrees actually obtained. In Table III and Fig. 5 are shown the cane yields per acre from 1911 to 1931 and the corresponding total warmth so calculated. In Fig. 6 the same data are presented as smoothed out curves to eliminate minor fluctuations and emphasize the trends only.

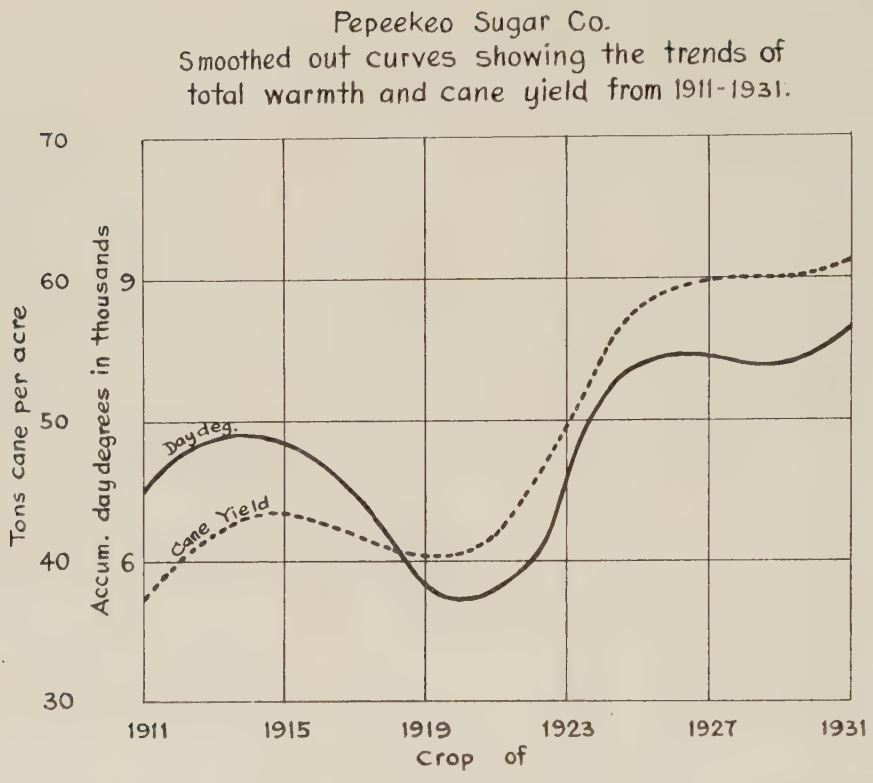

Fig. 6

The relation between total warmth and cane yield is very striking. It is the more remarkable considering that rainfall, which must be a factor in an unirrigated place like Pepeekeo, is not taken into account at all. Neither have we tried to correct for differential effect of temperature at diffrent levels or for cultural differences which are inevitably present from year to year.

From Pepeekeo, we pass on to the complicated case of the partly irrigated plantation—Honokaa Sugar Company. Table IV and Fig. 7 show the yield of cane and total warmth. The correspondence between the two is again striking. In all these years, Honokaa has passed through many varietal and cultural changes, but even so, temperature remains as the supreme influence.

One of the main reasons why temperature appears to control yield to such an extent in these Islands may be that in this subtropical climate a tropical, warmth-loving plant like the sugar cane does not generally obtain all the warmth it needs. Total warmth thus becomes a determining influence.

For want of satisfactory data, it has not yet been possible to study in detail this total warmth and yield relationship in any of our warmer plantations; but fragmentary evidence from the yield records of the Ewa Plantation Company tends to confirm our belief that even there, the above relation between total warmth and yield would generally hold true. (Also see Appendix—B.)

A Suggested Method of Utilizing Day Degrees for Estimating the Conditions of Current Crops

In the preceding pages an attempt has been made to measure the potential growth value of the different months of the normal year in terms of the average monthly maximum temperature of the place. It has also been suggested that these values can be used to estimate the potential yield value of crops of various lengths started at different times of the year.

A little thought will show that though these growth values are excellent for a general understanding and study of cropping schemes, they are far from satisfactory in evaluating the growth possibilities of current months for the simple reason that these months may be far from normal. To take an instance—the month of December, 1932, was 3° warmer in Honolulu than the previous December. In fact, the 1932 December was as warm as a normal spring month. Surely we would not want to take the growth value of a normal December to evaluate the growth of 1932 December.

This is just where the day-degrees come to our rescue. Why take the growth values obtained from consideration of day-degrees of a normal year? Why not take the day-degrees of this year, this month?

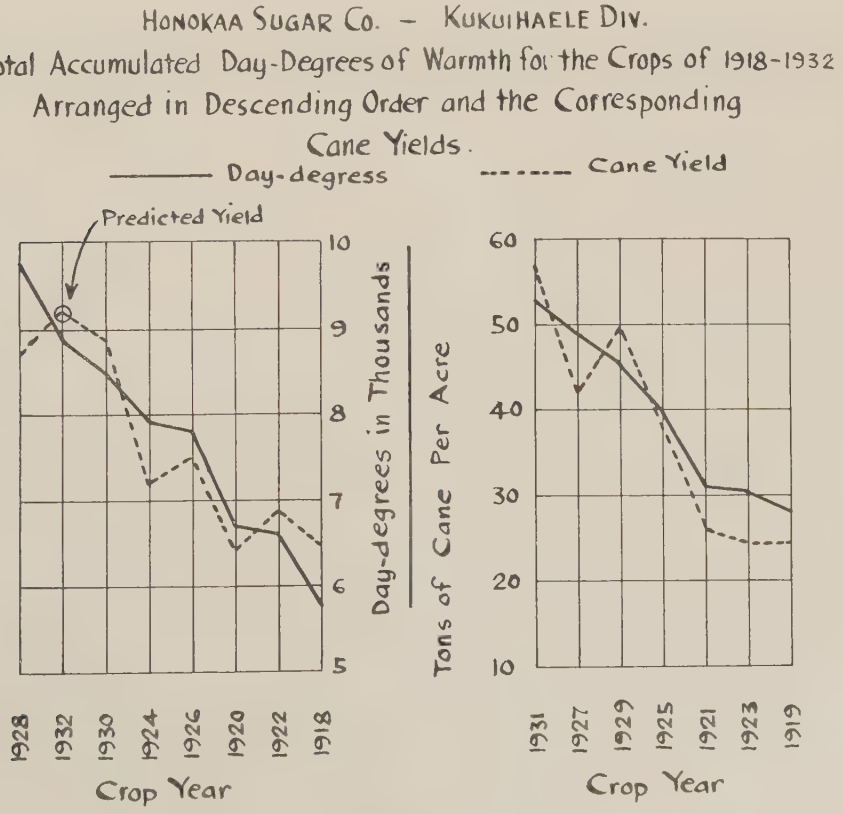

Fig. 7

Hereunder we suggest a scheme of summating the day-degrees for any crop from month to month which seems to offer attractive possibilities for measuring the progress of current crops. This method may be utilized for comparing the "condition to date" of one crop with another.

First, we determine the time of starting of the crop. Then referring to the temperature records, we obtain the actual day-degrees for the first month after starting. To this we go on adding progressively the actual day-degrees of each successive month to the time of harvest. In Table V and Fig. 8 we show the results obtained in this manner for two crops of the Honokaa Sugar Company, namely, the crop of 1920 and 1928. The month-to-month progress of temperature leaves no doubt in one's mind as to the advantage of the 1928 crop over the earlier one. The actual yield of 1928 was indeed very much higher than that of 1920. Similar charts drawn for a few other plantations tell the same story.

We are accustomed to chart the progress of field operations—irrigation, rainfall, fertilization, etc., of different crops for the purpose of comparison and agricultural control. Would not similar charts of the progress of temperature from month to month be of value in comparing one crop with another and in estimating their yield possibilities?

Discussion of the Methods—Their Drawbacks and Good Points

It is not denied that the methods herein suggested are far from perfect. The complex process of plant life—whose integrated expression total yield is—cannot be foretold or measured completely from considerations of temperature alone. There are other factors which must be reckoned with (but at the same time it must be admitted that where other factors remain more or less consant we should find growth and yield markedly influenced by the warmth received).

Herein we have considered only the average maximum temperature, but our previous study (10) has shown that minimum temperature is also a factor of importance. The fact that this minimum is so often correlated with maximum temperature probably explains the success of our efforts in evaluating the yield and temperature relationship of the Pepeekeo and the Honokaa Sugar companies.*

Besides the inter-relation and inter-dependence of temperature and other factors that concern growth, we have conditions within the plant that must also be considered. Can we assume for instance, that the same number of day-degrees will produce equal growth when the cane is six months old and when it is fifteen months old? In other words, should we not introduce a correction for differential rate of growth at various ages? Then there is the complicated factor of different plant processes each of which probably has a different optimum temperature.

But these obvious defects are inherent in all our agricultural measurements. We express yields in terms of acres, compare one field, one plantation with another on the basis of these figures. Can we say that one acre here is exactly

* Probably, soil temperature should also be considered. However, we know very little as yet concerning soil temperature of a cane field.

the same as one acre there? Are not we assuming that the other factors are constant? We measure yield in terms of pounds of plant food applied, in terms of gallons of irrigation water given to a crop; are any of these measurements, we submit, any more precise than the new measurements suggested in this paper? But none of us doubts the value of the accepted measurements in aiding our progress even though these measurements are far from perfect. In case of temperature we may at least say that it appears to influence yield to a greater degree than any other single factor we know of. (The factor of sunlight is associated with temperature.)

Heretofore, we have spoken of weather in a vague way. But here is at least one method by which we can express the temperature aspect of our weather in a

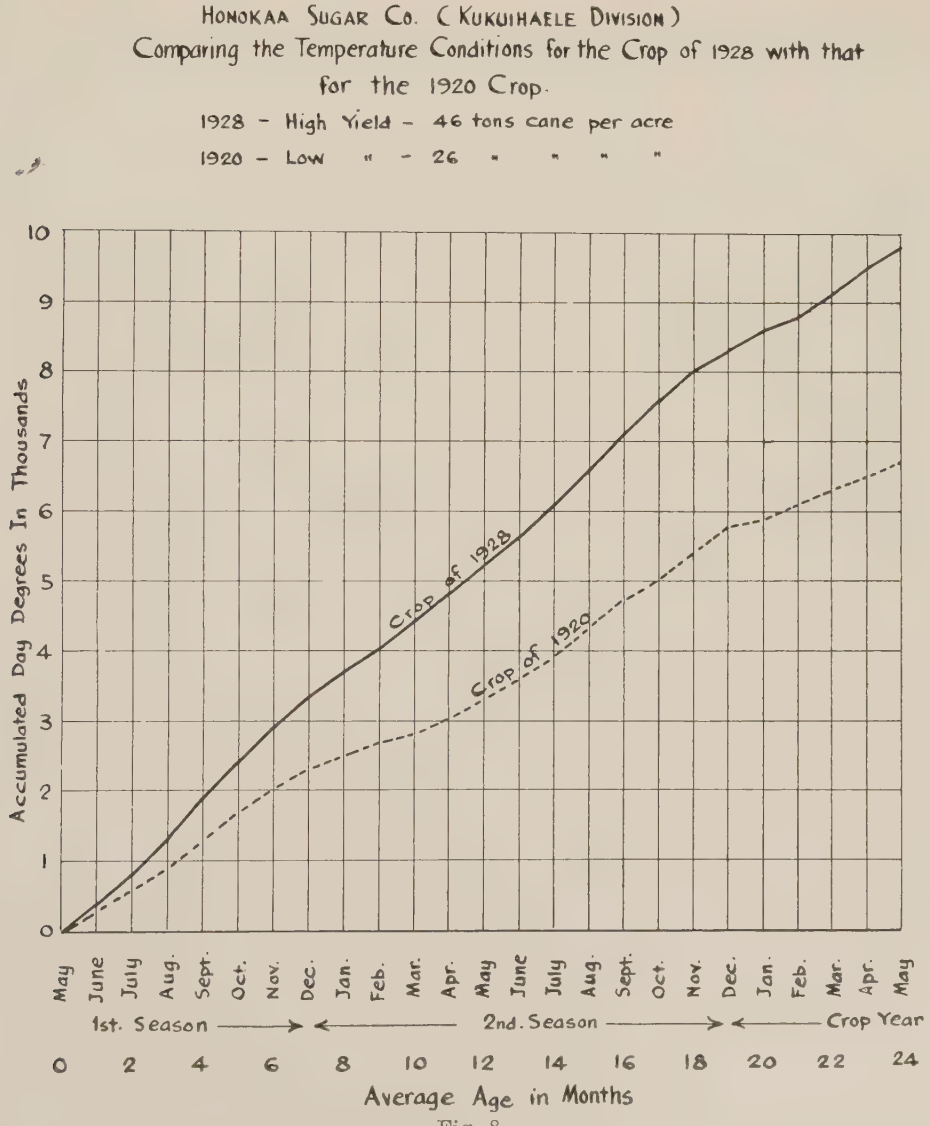
Honokaa Sugar Co. (Kukuihaele Division)
Comparing the Temperature Conditions for the Crop of 1928 with that for the 1920 Crop.
1928 - High Yield - 46 tons cane per acre
1920 - Low " - 26 " " " "
Accumulated Day Degrees In Thousands
0
1
2
3
4
5
6
7
8
9
10
Crop of 1928
Crop of 1920
May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May
1st. Season
2nd. Season
Crop Year
0 2 4 6 8 10 12 14 16 18 20 22 24
Average Age in Months

Fig. 8

quantitative manner. Heretofore, we have compared one plantation with another on the basis of soil, variety and other factors, but now we shall be in a position to compare them on the basis of climate.

However, in comparing one plantation with another or for that matter two widely separated fields of the same plantation, we will have to make sure that the temperature data are really representative of the conditions we are comparing.

It is possible that by bringing in other corrections (some of which are mentioned in this paper) an expression could be devised which might show an even better concordance with yield figures, but the complexity of the expression will probably hamper its wide use. The measurements here suggested are simple and the basic data are simply and inexpensively obtained.

Summary

In the foregoing pages, a method is suggested of evaluating warmth quantitatively in terms of day-degrees. A day-degree has been defined as one degree (F.°) temperature above an average maximum temperature of 70°. It has been shown that the potential growth values of the different months of the year can be approximately evaluated by the use of this conception of a day-degree. It has also been shown that there exists a close relation between cane yield per acre of a plantation and the total effective warmth received. A method has also been offered by which one can evaluate the crop conditions to date from the point of view of warmth.

The shortcomings and the advantages of these conceptions and methods are pointed out. It is, however, hoped that the present methods can be improved as more experience is gained from their use. But the present imperfections must not make us forget the fact that progress in science generally proceeds from first approximations to exactness, from imperfections to perfections; that even an approximate measure of one of our important resources is far better than none at all.

TABLE I

CALCULATION OF GROWTH VALUES FROM TEMPERATURE DATA

	EWA PLANTATION COMPANY				PEPEEKEO SUGAR COMPANY			
Month	Mean Max. Temp.	Avg. Day-degrees	Day-degree x No. of Days	% of Year's Total	Mean Max. Temp.	Avg. Day-degrees	Day-degree x No. of Days	% of Year's Total
January	78.6	8.6	267	5.6	77.5	7.5	233	6.5
February	79.6	9.6	269	5.7	78.0	8.0	224	6.3
March	79.9	9.9	307	6.5	77.6	7.6	236	6.6
April	81.6	11.6	348	7.3	77.9	7.9	237	6.6
May	83.7	13.7	425	8.3	79.4	9.4	291	8.2
June	85.3	15.3	459	9.7	80.2	10.2	306	8.6
July	86.2	16.2	502	10.6	81.3	11.3	350	9.8
August	86.8	16.8	521	11.0	81.9	11.9	369	10.4
September. ..	86.6	16.6	498	10.5	81.8	11.8	354	9.9
October	85.2	15.2	471	9.9	82.0	12.0	372	10.4
November	82.5	12.5	375	7.9	80.6	10.6	318	8.9
December	80.2	10.2	316	6.6	78.9	8.9	276	7.7
Total.....			4758				3566	

TABLE II

GROWTH VALUES CORRECTED BY APPLYING VAN'T HOFF'S LAW OF $Q_{10}=2$

Month	Mean Max. Temp.	Avg. Day-degrees	Correlated Values When August=100	% of Year's Total	Monthly % from Agee's 10:4 Ratio
January	78.6	8.6	39	4.7	4.7
February	79.6	9.6	39	4.7	4.7
March	79.9	9.9	47	5.7	6.7
April	81.6	11.6	57	6.9	8.1
May	83.7	13.7	74	8.9	10.3
June	85.3	15.3	84	10.2	11.1
July	86.2	16.2	95	11.5	12.2
August	86.8	16.8	100	12.1	11.7
September	86.6	16.6	95	11.5	10.0
October	85.2	15.2	86	10.4	8.3
November	82.5	12.5	63	7.6	6.7
December	80.2	10.2	49	5.9	5.6

TABLE III

PEPEEKEO SUGAR COMPANY
CANE YIELD PER ACRE AND TOTAL WARMTH

Crop of	Tons Cane per Acre	Accumulated Day-degrees	Order of Accumulated Day-degrees
1911	32.95	6711	16
1912	34.61	6765	15
1913	36.57	7554	11
1914	41.46	7582	10
1915	51.03	7202	13
1916	40.40	7532	12
1917	45.40	7654	9
1918	39.96	6026	17
1919	37.09	4769	20
1920	42.09	4744	21
1921	47.02	4915	19
1922	47.92	5821	18
1923	41.29	6988	14
1924	50.12	7718	7
1925	60.37	8156	5
1926	58.69	8580	2
1927	61.62	8243	4
1928	59.19	7725	6
1929	60.21	7681	8
1930	61.77	8464	3
1931	63.20	8902	1

TABLE IV

HONOKAA SUGAR COMPANY

(Kukuihaele Division)

CANE YIELD AND ACCUMULATED DAY-DEGREES

Crop of	Cane Yield	Accumulated Day-degrees
1918	24.8	5721
1919	24.6	6888
1920	23.5	6738
1921	26.3	7083
1922	28.9	6559
1923	24.5	7034
1924	31.5	7962
1925	38.0	7965
1926	35.0	7800
1927	41.5	8908
1928	47.0	9820
1930	49.0	8533
1929	49.7	8551
1931	57.7	9307

TABLE V

HONOKAA SUGAR COMPANY

(Kukuihaele Division)

MONTH TO MONTH PROGRESS OF ACCUMULATED WARMTH FOR THE CROPS OF 1928 AND 1920

	Crop 1928	Crop 1920
1st Season:		
May	384	251
June	828	551
July	1336	883
August	1860	1264
September	2355	1660
October	2876	2035
November	3305	2338
December	3674	2518
2nd Season:		
January	4024	2673
February	4416	2841
March	4835	3039
April	5216	3285
May	5638	3561
June	6091	3897
July	6593	4272
August	7123	4653
September	7591	5022
October	8003	5419
November	8321	5758
December	8569	5885
Crop Year:		
January	8842	6074
February	9097	6287
March	9469	6513
April	9820	6738

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TECHNICAL APPENDIX A

Quantitative relation between temperature and growth. Is it linear or non-linear?

In the body of the report it has been stated that actual measurements of cane growth lead us to believe that there exists a definite quantitative relationship between maximum temperature above 70° and cane elongation. In this report this relationship has been assumed to be linear, though it has been admitted that probably the true relationship would be more correctly expressed by a curve derived from other theoretical considerations—such as the application of Van't Hoff's Law. The following is a fuller discussion of the subject than that attempted in the main body of the report.

Here are some data on cane growth obtained in a test at the Experiment Station, H. S. P. A., Honolulu, in 1926. The cane was given optimum fertilization and irrigation, so that these two factors could not be limiting. The average elongation of 100 to 200 stalks of different ages was recorded every two weeks.

TABLE I

Average Elongation in Feet	Mean Maximum Temperature	Average Elongation for a 10-Day Period
0.49	80.1	0.35
.32	77.4	.23
.48	81.1	.34
.74	83.4	.53
.80	83.3	.57
.81	83.7	.58
.80	83.4	.57
.93	85.6	.67
Average.....	82.25	.48

In Fig. 9 the average daily elongation is plotted against temperature, and the line of best fit determined mathematically. (An inspection of the data will show that the recorded elongation indicates a linear relationship with temperature.) The equation for the line is:

$$y = 0.48 + 0.0558\ (t - 82.25)$$

Where y = elongation in feet for a 10-day period

t = mean maximum temperature for the period

The equation shows that $y = 0$, when $t = 73.65$. In other words the present data would indicate the zero point of elongation to be as high as 73.65°, assuming the relation to be linear beyond the range of temperature obtained in this experiment. But it will be noticed that we have no actual elongation data for temperature below 77° maximum. Therefore, we cannot be certain that the elongation would really fall off so rapidly below 77° as to become zero at 73.65°.

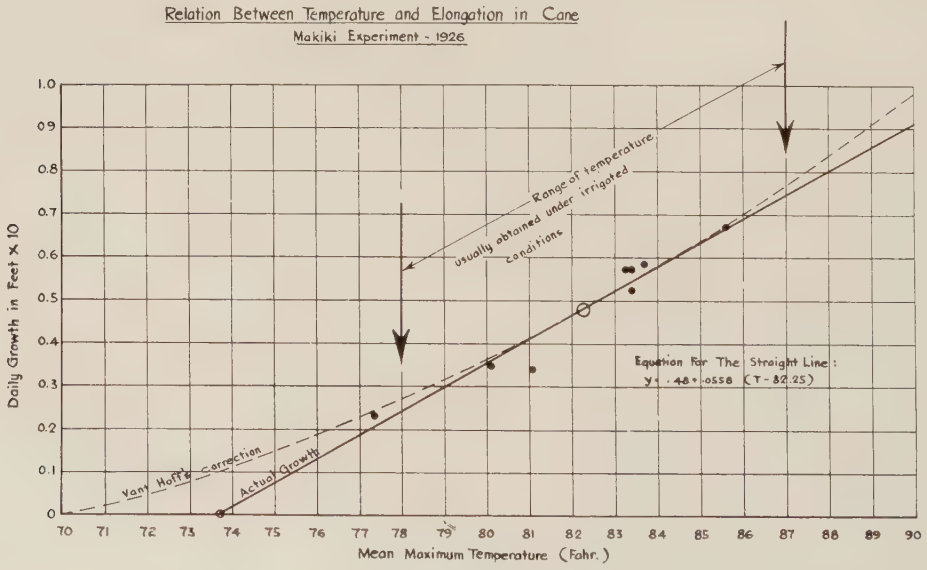
Relation Between Temperature and Elongation in Cane
Makiki Experiment - 1926
Daily Growth in Feet X 10
Mean Maximum Temperature (Fahr.)
Range of temperature usually obtained under irrigated conditions
Equation For The Straight Line:
y = .48 + .0558 (T - 82.25)
Van Hoff's correction
Actual Growth

Fig. 9

Let us now estimate the elongation that we should obtain from assuming 70° of maximum temperature as the zero point of growth and that Van't Hoff's Law applies. We are now to find, if 82.25° produces an elongation of 0.48 foot, what should be the elongation at the other temperatures actually obtained in the experiment. Van't Hoff's Law states that the velocity of chemical reaction increases from one to two for every 18° F. rise of temperature. Assuming a uniform increase in the rate, between the limits of 70° and 88°, we calculate the velocities at different temperatures to be $\left(1 + \frac{t - 70}{18}\right)$. Multiplying this calculated velocity by the number of day-degrees, we obtain the relative units of elongation to be obtained under different temperature conditions. Table II and Fig. 9 give the values thus obtained.

TABLE II

Mean Maximum Temperature	Day-degrees	Reative Units of Growth When 71° = 1	Growth in Feet When 82.25° = 0.48 Foot
72°	2	2.25	0.05
74	4	4.90	.11
76	6	8.00	.19
78	8	11.54	.27
80	10	15.60	.36
82.25	12.25	20.59	.48
84	14	25.00	.58
88	16	36.00	.84

The relation between temperature and elongation is now seen to be non-linear, and in greater accord with known facts of plant physiology. However, Fig. 9 shows clearly that over the range of temperature obtained in this experiment (the same limited range of temperature exists between the winter and the summer months of our plantations) the straight line gives substantially the same values as the curve. For the sake of simplicity, we may then assume the straight line to be a good first approximation to the true relationship.

TECHNICAL APPENDIX B

Accumulated Day-Degrees and Yield

The final test of the soundness of the suggested measures would be—how far do the actual yields correlate with total warmth when other growth factors are more or less constant?

In the body of the report, it has been shown that in general there is a very good agreement between total warmth and per acre yield of some plantations. In the case of Pepeekeo, the correlation between total warmth and yield per acre for 22 crops (1911-1932) is found to be + .63. This is indeed a very high correla-

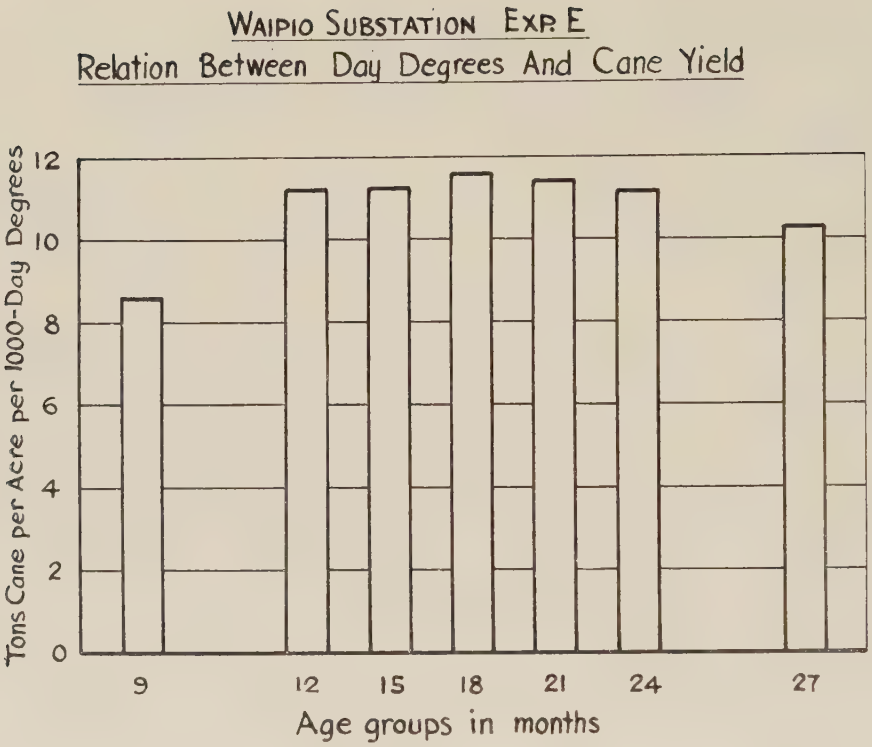

Fig. 10

tion, especially when we remember that no adjustment had been made in the yield data to allow for agricultural progress or cultural changes.

The data produced hereunder show that under more or less uniform cultural conditions there actually exists a greater correlation between total warmth and yield.

In Experiment E (1927-1929) at Waipio Substation of the H. S. P. A., the rate of cane yield with age was studied in relation to time of planting and harvesting. The harvesting results and other calculations are tabulated below:

VARIETY H 109—PLANT CANE ONLY

No. of Harvests	Age at Harvest (Calendar Months)	Tons Cane per Acre	Accumulated Day-degrees From the Date of Planting to Harvest	Tons Cane per 1000 Day-degrees
1	9	23.5	3484	6.7
2	10	39.5	3898	10.1
3	10	31.4	3692	8.5
4	7	26.4	2954	8.9
Average	9	30.2	3507	8.6
5	12	54.8	4987	11.0
6	12	45.9	4735	9.7
7	12	53.8	4706	11.4
8	12	53.1	4586	11.6
9	12	53.4	4284	12.5
Average	12	52.2	4660	11.2
10	15	70.7	6238	11.3
11	15	59.5	5543	10.7
12	15	65.1	5600	11.6
13	15	66.3	5916	11.2
14	15	59.3	5286	11.2
Average	15	64.2	5717	11.2
15	18	91.6	7046	13.0
16	18	72.2	6437	11.2
17	18	90.2	6930	13.0
18	18	68.6	6918	9.9
19	18	66.4	6123	10.9
Average	18	77.8	6691	11.6
20	19	107.6	7940	13.6
21	21	99.5	7767	12.8
22	22	80.0	7932	10.9
23	23	70.0	7755	9.0
Average	21	89.3	7849	11.4
24	24	125.6	9270	13.6
25	24	90.0	8769	10.3
26	24	82.0	8769	9.4
Average	24	99.2	8936	11.1
27	27	108.9	10272	10.6
28	27	96.4	9606	10.0
Average	27	102.6	9939	10.3

Fig. 10 shows the average tons of cane per 1000 day-degrees for the different age groups. We note that this average is practically the same for canes of 12 to 24 months of age, but that it falls off below 12 months and above 24 months. The low averages for very young and very old cane are explained by the fact that in the one, cane has had hardly enough time to form and that in the other, deterioration has set in. But the fact that the average figure for tons cane per acre per 1000 day-degrees is practically the same between 12 and 24 months of age, further confirms our assumption that the relation between growth and day-degrees is approximately linear within the limited range of temperature obtained on our plantations, and that accumulated day-degrees give a satisfactory measure of total effective warmth for crops that are neither too old nor too young.

A dot chart correlating yield and total day-degrees shows that the great deviations from the straight line of best fit were obtained only in the case of the old canes. From our knowledge of the details of this experiment we have reasons to believe that some of these latter harvests were not strictly comparable to the rest.

Without making any corrections for any known differences or without discarding any of the data we have correlated the yields with accumulated day-degrees.

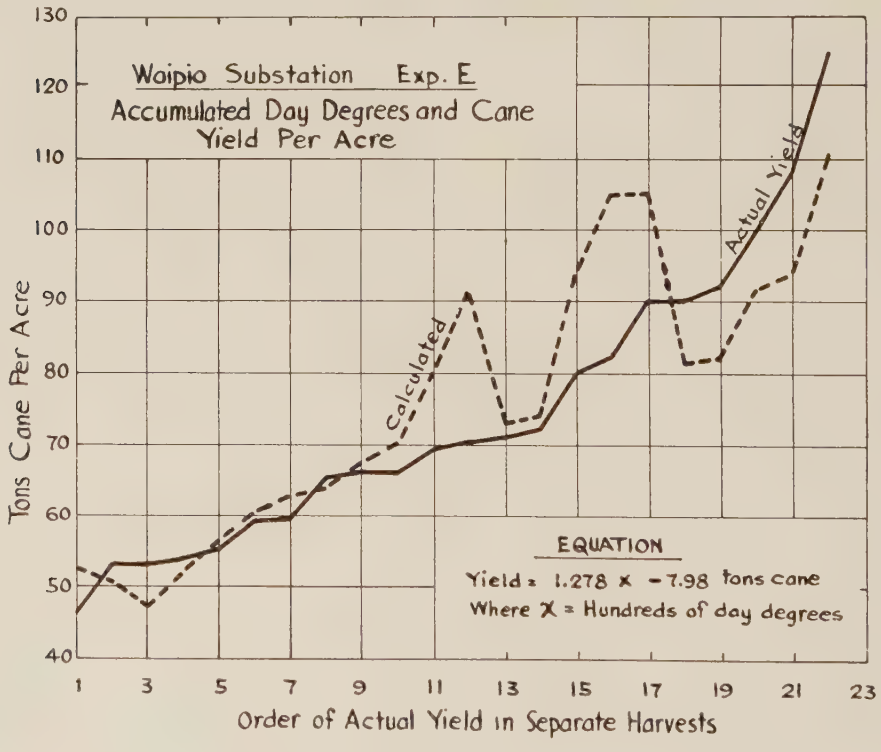

Fig. 11

The coefficient of correlation is + .899 for canes 12 to 18 months of age, + .852 when cane 21 months old is included and + .848 when all the harvests from 12 to 24 months are taken.

The magnitude of these coefficients leaves no doubt in one's mind that under uniform cultural conditions, accumulated day-degrees is the determining factor in cane yield.

Further study of the data shows that the correlation between yield and total day-degrees is closer than that between yield and age, that in this experiment tons cane per acre per 1000 day-degrees give us a better measure than tons cane per acre per month. This should not be wondered at for the expression "total day-degrees" includes the element of time.

The Effect of Various Intensities of Light on the Growth of the H 109 Variety of Sugar Cane

By J. P. Martin and R. C. Eckart

Introduction

Plant life is characterized by a continuous accumulation of organic compounds which are not absorbed from the environment in an elaborated condition, but are synthesized in the body of the plant itself from simpler substances taken by the plant from its surroundings. The first step in this process is called photosynthesis and is dependent upon light as a source of energy. This photosynthetic activity is also dependent upon the green pigment, chlorophyll, which is found in all green plants in specific cell inclusions called chloroplasts. The formation of this green pigment is also dependent upon light as well as temperature, oxygen, iron, and the amount of carbohydrates in the leaf. Thus, the importance of light consists in the fact that it is necessary for breaking the strong linkage between oxygen and carbon to produce certain carbohydrates, principally sugars. These carbohydrates are then transformed by further synthesis and enzyme activity without the aid of light into dozens of substances which go to make up the various parts of the plant.

Thus, the role of light in plant growth is one of major importance to the proper functioning of the photosynthetic process which supplies the plant with the food materials necessary for its normal growth. The assimilation of the products of photosynthesis within the leaf to form these plant food materials, and their eventual storage, is closely associated with photosynthesis. When this process of assimilation terminates with the formation and storage of sugars, the plants are called "saccharophilous" in distinction from "amylophilous," or plants which form and store starch.

Sugar cane being a light-loving and at the same time a saccharophilous plant, requires a large amount of light for the manufacture of sugar. When grown in the dark, the storage of sugars is greatly reduced and there is a marked accumulation of starch in the leaves, which is formed from not only the sugars: glucose, fructose, sucrose, galactose, mannose, and maltose, but also from other organic compounds. This fact is of primary importance, but closely associated with it are other growth peculiarities which tend also to reduce the amount of sugar manufactured and stored by the plant. It is with these latter abnormalities that this paper deals, and as no attempt was made to keep accurate temperature records or records of light intensity, photosynthetic rate, respiration, and the composition of the surrounding air, shade may be considered, for this purpose, the limiting factor of growth. It was realized that absolute scientific control of these factors would be impossible, so this experiment can merely be considered a "preliminary observational test" of the formative effects of various intensities of light on the growth of the H 109 variety of sugar cane.

Some idea of the degree of light intensity under the three conditions mentioned in this paper may be had by referring to Fig. 1.

Apparatus

The apparatus used consisted of two separate frames covered with one and two layers of unbleached muslin, respectively. The first will be referred to as Group II and the second as Group III, Group I being exposed to greenhouse conditions. Each group consisted of six 2-gallon pots arranged in a circle and supplied with a standard nutrient solution by the constant drip method from a 5-gallon bottle set in the center on a pedestal. Fig. 2 shows this method of feeding the plants and gives some idea of the construction of the test.

The variety of cane used was H 109, started from "top" three-eye cuttings. The young shoots were removed from the cuttings after suitable shoot roots had developed. The shoots were then planted in the pots in screened black sand and allowed to remain in the open for one week before subjecting them to the various light intensities.

Results

In less than a month the plants began to show definite changes, the most noticeable being the rapid growth of secondary shoots in Group I and the absence of shoots in the other two groups. The following illustration, Fig. 3, of Group I, taken on October 5, 1932, shows the numerous secondary shoots which have appeared and grown vigorously at the expense of the primary stalks. The leaves at this stage were normal as to width, texture, and color.

The next illustration, Fig. 4, of Group II, was taken on October 5, 1932, and shows the absence of secondary shoots and the stimulated growth of the primary stalks.

Fig. 5, of Group III, was also taken on October 5. The excessive shading of this group has stunted the growth of the plants in four ways: (1) spindly stalk, (2) narrow leaves, (3) no secondary shoot growth, and (4) exceptionally small root systems. Note the unusual length of the leaves.

The leaves of the plants in this group were a yellowish green in color and showed a tendency to dry up rapidly. The stalks were soft and although they grew rapidly for a short period, growth practically ceased after two months.

On October 5, two pots from Group I were transferred to Group III and two pots from Group III were transferred to Group I. The illustration shown in Fig. 6 was taken on October 5. Pots A and B are from Group III and Pots C and D are from Group I.

Within 10 days after this transfer, the plants moved from Group III to Group I, Pots A and B, began to send out secondary shoots, the new leaves became broader and greener and the primary stalks slowed up in growth. The plants moved from Group I to Group III, Pots C and D, became yellowish in color, many of the secondary shoots began to die, the new leaves came in narrow and the growth of the primary stalks was greatly increased.

The test was harvested on December 9, 1932, and representative plants from each group were photographed. Fig. 7 shows two plants from Group I. Their general appearance is one of vigor and normal condition. The plant on the left has 13 secondary shoots and the one on the right has 12.

In all cases the oldest secondary shoots outgrew the primary stalks at the expense of the latter. Fig. 9 shows two plants from Group II. The absence of secondary shoots and the excessive growth of the primary stalks are the outstanding features as compared with the plants shown in Fig. 7.

The stalks of these plants, Fig. 9, were heavy, the leaves normal as to color and width, but abnormally long and brittle. Fig. 8 shows two plants from Group III. Growth in this case became stunted after about two months, the leaves were pale in color, narrow, and elongated, with a tendency to dry out rapidly and shrivel up. The primary stalks were spindly and soft. The absence of secondary shoots is significant. The root systems were so small and shallow that they were barely able to support the plants in an upright position. These plants could not have survived this treatment for many more weeks.

Figs. 10 and 11 are of the plants which were moved from Group III to Group I (Pots A and B) and from Group I to Group III (Pots C and D), respectively.

Note the growth of secondary shoots in Pots A and B. These shoots appeared in less than 10 days after subjecting the plants to the light. The leaves became greener, wider, and normal in texture. The stalks became thicker and more rigid, and the new roots arising from the young secondary shoots, imbedded themselves throughout the entire "soil mass."

The secondary shoots in Pots C and D almost completely died out in less than six weeks after subjecting the plants to the shade of Group III. Growth of the primary stalks was stimulated, the leaves became elongated, brittle and pale in color. The plants as a whole, acquired all the light-deficiency symptoms of the other plants in this group. Table I gives the green and dry weights of all the plants and Charts I and II represent these weights graphically.

One of the most interesting disclosures at harvest was the condition of the root systems, those of Group I filling the whole pot, those of Group II occupying about one-half the space, and those of Group III being so meager that they were barely able to support the plants. This corresponds to the findings of one investigator in his studies of deciduous tree seedlings. He reports: "If the environment is unfavorable, especially as regards insufficient light, the root system is a miniature of the one that develops under favorable conditions." (1)

Another investigator working with various plants has reported the following: (2)

1. The per cent of dry matter increases with increasing light intensity.
2. The dry weight is directly proportional to light intensity.
3. With decreasing light intensity the plants tend to increase height.
4. Density of growth is increased with increasing light intensity.
5. There is a tendency to increase the chlorophyll concentration with decreasing light intensity until a critical intensity is reached. Further decrease in light intensity causes a decrease in the chlorophyll concentration.
6. Low light intensities tend to produce vegetative growth at the expense of flowers and fruit, top growth at the expense of root growth, large leaf area at the expense of leaf thickness (this does not seem to be true of the sugar cane plant) and succulence at the expense of sturdiness.

The abnormalities of sugar cane growth under shade, as referred to in this paper, are of course, closely associated with photosynthesis, in fact they are due to the abnormal or reduced functioning of the photosynthetic process in consideration of light intensity alone. So sensitive is the sugar cane plant to light that even the shade which occurs in the rows will cause abnormal growth and death to the young shoots, and many successive days of cloudy weather will greatly hinder the normal function of photosynthesis, thus causing a reduction in the sugar content of the plant.

Summary

Sugar cane, being a saccharophilous and a light-loving plant, is sensitive to changes in light intensity. The major formative changes which the plants in this test underwent, under the various conditions of light intensity, may be summarized as follows:

Decreased light itensity:

1. Increases the height of the primary stalk.
2. Hinders secondary shoot development.
3. Causes the leaves to become narrow, elongated, and brittle.
4. Greatly reduces root development.
5. Increases the concentration of chlorophyll in the leaves up to a certain decreased intensity. A further decreased intensity decreases the chlorophyll concentration.
6. Reduces the per cent of dry matter.

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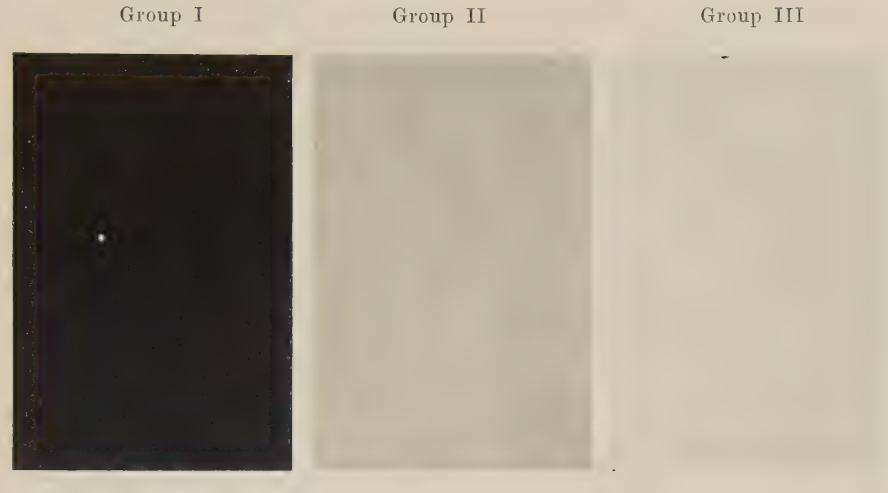

Fig. 1. Ten-minute exposures of 35 speed blue print paper under various conditions of light intensity. (10 a. m., August 11, 1932.)

Fig. 2. Showing the method of growing H 109 cane plant (Group II) in reduced light. The method used in applying the nutrient solution is also shown.

Fig. 3. Group I, showing H 109 cane plants, 56 days old, exposed to greenhouse conditions. Note secondary growth in each pot.

Fig. 4. Group II, showing H 109 cane plants, 56 days old, shaded by one layer of muslin. Note the absence of secondary shoots and stimulated growth of the primary stalks.

Fig. 5. Group III, H 109 cane plants, 56 days old, shaded by two layers of muslin. Note the absence of secondary shoots and the retarded growth of the plants as compared with those plants in Fig. 4.

Fig. 6. H 109 cane plants, aged 56 days. Pots A and B were moved from Group III to Group I, while Pots C and D were moved from Group I to Group III.

Fig. 7. H 109 cane plants from Group I, 120 days old. Grown under greenhouse conditions. Note development of secondary shoots.

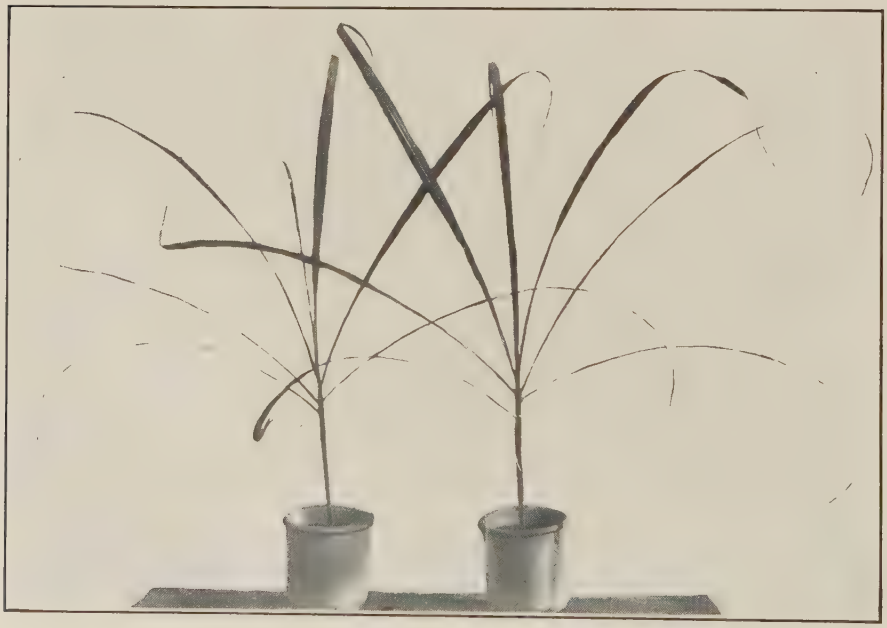

Fig. 8. H 109 cane plants from Group III, 120 days old, shaded by two layers of muslin. The primary stalks were considerably smaller than those in Group II. The leaves were unusually narrow and elongated. No secondary growth developed in these pots.

Fig. 9. H 109 cane plants from Group II, 120 days old, shaded by one layer of muslin. No secondary growth developed in these pots, but the primary stalks were larger than those in Groups I and III.

Fig. 10. These plants, at an age of 56 days, were transferred from Group III to Group I (see Fig. 6). Note development of secondary shoots after an exposure of 64 days to greenhouse conditions.

Fig. 11. These plants, at the age of 56 days, were transferred from Group I to Group III (see Fig. 6). Practically all the secondary shoots died, while the growth of the primary stalks was stimulated after an exposure of 64 days to reduced light conditions in Group III.

Total Green Weight in Grams of H109 Grown under Various Intensities of Light.

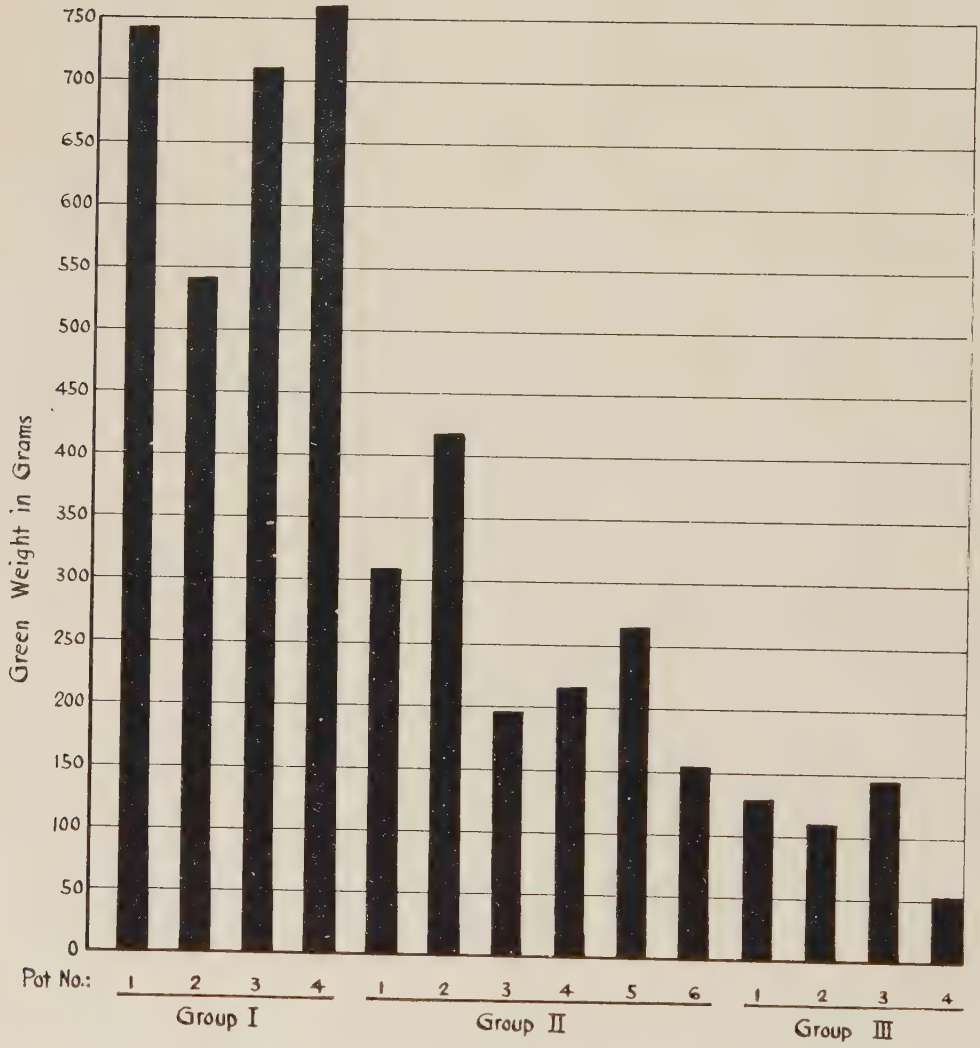

Chart I

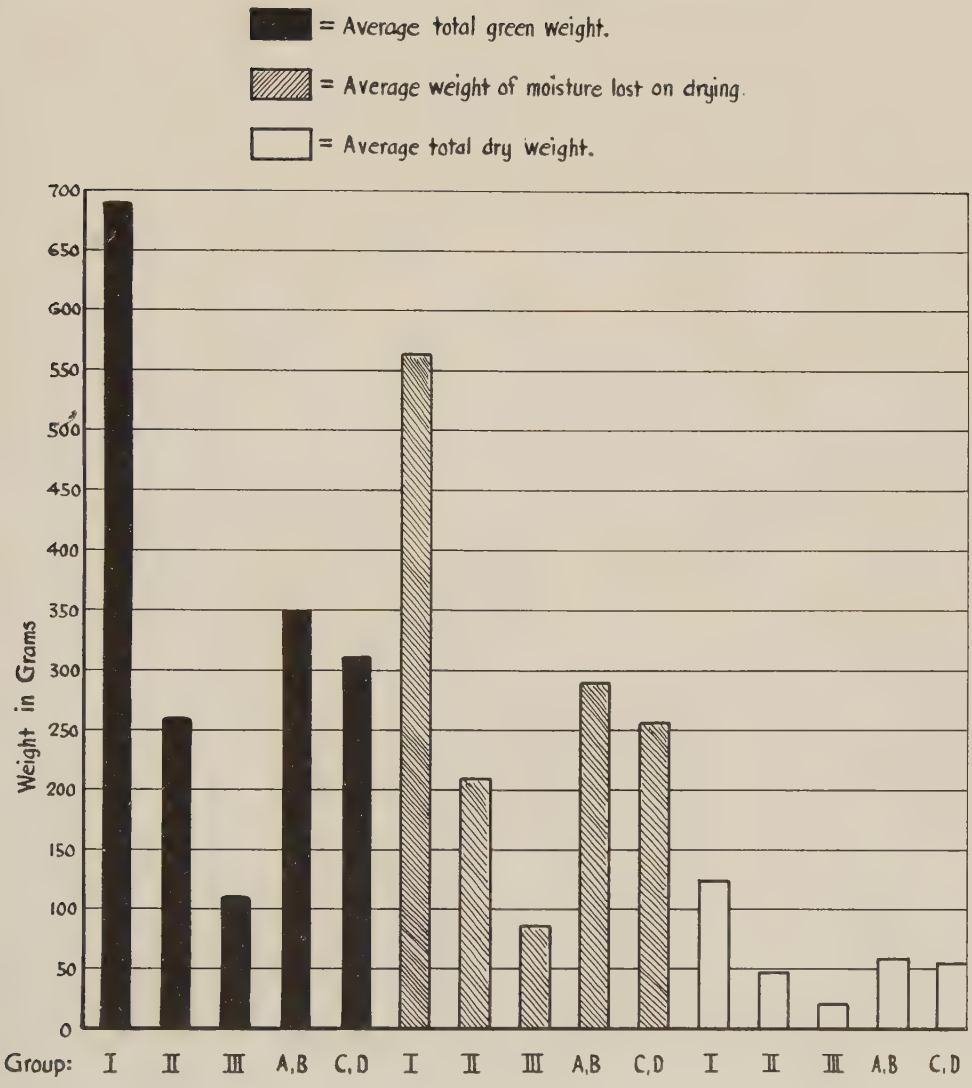
= Average total green weight.
= Average weight of moisture lost on drying.
= Average total dry weight.
Weight in Grams
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Group: I II III A,B C,D I II III A,B C,D I II III A,B C,D

Chart II

Green and Dry Weights in Grams of H109 Grown under Various Intensities of Light from Aug. 15 to Dec. 9, 1932.

Group	Pot No.	Green Weight	Dry Weight	Amount of Moisture Lost	No. of Shoots	Remarks
I Green-House Conditions	1	743.1	102.3	640.8	8	Excellent root development.
	2	542.5	90.0	452.5	12	
	3	710.3	140.0	570.3	13	
	4	763.0	168.1	594.9	10	
Average per Pot		689.72	125.1	564.62		
II Shaded With One Layer of Muslin	1	310.6	59.7	250.9	0	Root about half the size of those of Group I
	2	419.0	74.3	344.7	0	
	3	198.7	41.1	157.6	0	
	4	218.1	39.9	178.2	0	
	5	265.1	50.8	214.3	0	
	6	156.7	30.8	125.9	0	
Average per Pot		261.36	49.4	211.96		
III Shaded With Two Layers of Muslin	1	130.0	25.9	104.1	0	Roots barely able to hold the plants upright.
	2	111.5	24.5	87.0	0	
	3	146.5	27.0	119.5	0	
	4	52.3	10.0	42.3	0	
Average per Pot		110.07	21.85	88.2		
Moved From III to I on Oct. 5	A	275.0	44.2	230.8	6	Excellent root development.
	B	427.8	72.3	355.5	10	
Average per Pot		351.4	58.25	293.15		
Moved From I to III on Oct. 5	C	214.3	37.6	176.7	Died	Poor root systems.
	D	412.6	72.6	340.0	Died	
Average per Pot		313.45	55.1	258.35		

Annual Synopsis of Mill Data

By W. R. McAllep and W. L. McCleery

This is the ninth successive season in which production has exceeded previous records. During the year ending approximately September 30, the period covered by these data, factories in the Association produced 1,016,843 tons of sugar, an increase of 3 per cent over last year.

All factories in the Association have submitted data for this Synopsis. The number has been reduced from 39 to 38 as factory operations have been discontinued at Olowalu, following the consolidation of this plantation with Pioneer.

Factories are listed in the tabulations in the order of the average size of the crop for the past five years unless otherwise noted, and in other respects data are presented in a form closely comparable with previous Synopses. Some reductions in tabulated matter have been made where data are no longer as useful as in the past or where changes in data from year to year are small enough to warrant publication at less frequent intervals. The table of Apparent Boiling House Recovery has been discontinued as all but three factories now report sucrose data. The Summary of Losses also has been discontinued as losses calculated as a percentage of the pol in cane are readily available in the first of the large tables. Losses per cent cane and milling machinery have been omitted from the first of the large tables. Several items of mill data customarily included in a second and third large table have been omitted for this season, enabling us to combine these tables.

Varieties of Cane

Eight varieties have been ground to the extent of 1 per cent of the total crop, an increase of two. One of these, Badila, was included in Table 1 two years ago. Uba appears for the first time.

Yellow Caledonia and D 1135 together make up approximately a third of the crop, and H 109 somewhat more than one-half. P. O. J. 36 leads the less important varieties by a comfortable margin.

Increases over last season are recorded for H 109 and P. O. J. 36, and decreases for Yellow Caledonia, D 1135, Yellow Tip and Striped Tip. Considering the biennial nature of the crop, however, the trend is probably toward an increase rather than a decrease in D 1135. Also H 109 has probably passed the peak in percentage, notwithstanding the small increase over last season and a larger total tonnage than in any previous year.

The increase in P. O. J. 36 brings this variety from fifth to fourth place. It now shares with D 1135 the distinction of being the most widely distributed variety, both being reported from 25 factories.

The decline in the proportion of Yellow Caledonia continues steadily. Yellow Tip is decreasing rapidly, the proportion being less than half of the maximum

TABLE NO. 1
MAJOR VARIETIES OF CANE
(One per cent or more of total crop)

	H 109	Y. C.	D 1135	P. O. J. 36	Yellow Tip	Striped Tip	Badila	Uba	Others
H. C. & S. Co.	100	...	...	..	..	..	..	..	...
Oahu	98	...	1	..	..	..	..	..	1
Ewa	99	...	...	..	..	..	..	..	1
Waialua	96	...	1	..	..	..	..	..	3
Maui. Agr.	96	...	...	..	..	..	..	..	4
Pioneer	96	...	1	1	..	..	..	..	2
Lihue	48	...	3	17	14	..	10	..	8
Olaa	...	75	19	6	..	..	..	..	...
Haw. Sug.	99	...	1	..	..	..	..	..	...
Kekaha	97	...	...	..	..	..	..	..	3
Honolulu	98	...	...	2	..	..	..	..	...
Haw. Agr.	...	39	50	1	..	..	..	..	10
Onomea	...	81	5	8	4	..	..	..	2
Hilo	...	87	9	2	..	..	..	..	2
Honokaa	2	1	68	8	..	..	..	17	4
Makee	53	11	...	9	8	..	7	..	12
McBryde	84	...	6	5	1	..	..	..	4
Wailuku	95	...	...	..	..	..	..	..	5
Hakalau	...	65	18	8	7	..	..	..	2
Kahuku	96	...	...	1	..	..	..	..	3
Laupahoehoe	...	22	68	2	7	..	..	..	1
Koloa	67	2	...	15	4	..	..	..	12
Waiakea	...	96	2	..	..	..	..	..	2
Hamakua	...	...	84	..	9	..	..	..	7
Pepeekeo	...	90	4	3	2	..	..	..	1
Hutchinson	...	24	54	16	..	..	..	..	6
Paauhau	...	...	57	18	14	..	..	..	11
Kohala (Hawi)	...	...	13	10	..	47	..	..	30*
Kohala	...	...	29	4	..	15	..	..	52†
Honomu	...	83	10	4	..	..	..	..	3
Kaiwiki	...	9	88	..	1	..	..	..	2
Waimanalo	61	...	...	23	..	..	..	..	16‡
Kilauea	3	4	...	4	14	1	28	35	11
Waianae	100	...	...	..	..	..	..	..	...
Kaeleku	...	94	1	2	..	..	..	..	3
Union Mill	...	...	12	13	..	65	..	..	10
Niulii	...	...	45	9	..	36	..	..	10
Waimea	99	...	...	..	..	..	..	..	1
True Average 1932	54.5	17.6	13.4	4.1	2.1	1.5	1.0	1.0	4.8
" " 1931	54.2	18.8	13.7	2.6	3.0	2.1	0.7	0.9	4.0
" " 1930	56.6	19.9	12.3	0.7	3.5	1.6	1.2	0.7	3.5
" " 1929	53.1	21.5	13.0	0.3	4.3	2.1	0.5	0.7	4.5
" " 1928	54.7	20.7	12.9	..	4.9	2.2	0.3	0.5	3.8
" " 1927	53.1	23.7	11.8	..	4.0	1.6	0.4	0.1	5.3
" " 1926	48.7	25.6	12.1	..	4.5	2.1	0.5	..	6.5
" " 1925	42.7	30.7	11.9	..	2.7	2.1	0.4	..	9.5
" " 1924	38.1	32.6	12.0	..	2.3	2.0	0.1	..	12.9
" " 1923	30.7	36.3	11.2	..	1.2	1.6	0.2	..	18.8

* K107, 23%
† K107, 44%
‡ P. O. J. 2878, 6%

reached in 1928. Though Striped Tip makes up but a small proportion of the crop, and often fluctuations from one season to the next have been relatively large, this variety has maintained its relative position more consistently than any other during the whole of the 15-year period for which figures are available. Maximum and minimum percentages have been 2.6 and 1.5 respectively.

Minor Varieties: This classification includes varieties making up 1 per cent of the crop of any factory. The following 16 have been reported:

MINOR VARIETIES

One Per Cent or More of the Crop of Any Factory

1. K 107	5. H 456	9. St. Mex.	13. McB. 6
2. UD 1	6. P O J 2878	10. Manoa 213	14. UD 79
3. K 202	7. P O J 213	11. K K 456	15. N Uba
4. H 8965	8. UD 50	12. H 8906	16. Nalo 13

The above are listed in the order of the tonnage as reported, but this order may not be particularly accurate as small quantities of minor varieties are often omitted from Synopsis reports. The amount of K 107 reported was but slightly less than 1 per cent of the total crop.

Rose Bamboo and D 117 have disappeared from the minor variety classification this year, having joined Lahaina in the group of former major varieties which no longer appears even in the minor variety classification.

Six of the above varieties appear in the Synopsis for the first time. Among these may be mentioned P. O. J. 2878, which was reported from 12 factories and on its first appearance makes up .22 per cent of the total crop.

Quality of Cane

The quality of cane is poorer than last season to the extent of .12 of a ton of cane per ton of sugar. In 1927 only was the quality poorer, the average quality ratio then being 8.91 against the present average of 8.84.

Averages for fiber per cent cane do not indicate changes of any particular significance in the last few seasons.

In one respect the cane has been better; that is, purities have improved. This holds true for all Islands, though the improvement in purity on Hawaii has been very small. The decrease in cane quality is on account of lower pol, this having much more than offset the improvement in purity. Oahu is the only island where the pol has increased. With this increase, and better purity, the quality has improved .15. Decreases in quality on Kauai and Maui have been of about the same order as the improvement on Oahu. The decrease on Hawaii is equivalent to .4 in quality ratio, bringing the quality ratio to above 10, the poorest yearly average on record for any island. The decrease in quality on the island of Hawaii is principally responsible for the decrease in the average quality this season.

Decreases on the island of Hawaii are also responsible for a large part of the perturbing decrease in the average quality of cane during the past 15 years. Data on trend in cane quality during this period, as calculated by the usual method of least squares, follow. Trends for both quality ratio and the corresponding yield per cent cane are given, but the latter should be used for comparative purposes.

TABLE NO. 2

COMPOSITION OF CANE BY ISLANDS

	Hawaii	Maui	Oahu	Kauai	Whole Group
1923					
Pol	12.09	13.61	12.99	12.94	12.78
Per cent Fiber	13.14	12.01	12.86	12.99	12.82
Purity 1st Expressed Juice	87.61	88.65	85.52	86.58	87.05
Quality Ratio	9.04	7.86	8.43	8.36	8.50
1924					
Pol	12.44	14.34	13.48	13.34	13.26
Per cent Fiber	12.99	12.16	12.72	12.94	12.74
Purity 1st Expressed Juice	87.98	89.19	87.02	87.31	87.86
Quality Ratio	8.78	7.53	8.10	8.06	8.19
1925					
Pol	12.35	14.42	13.52	13.24	13.22
Per cent Fiber	12.92	12.40	12.60	12.91	12.74
Purity 1st Expressed Juice	88.02	89.36	87.11	87.19	87.92
Quality Ratio	8.84	7.42	8.12	8.15	8.22
1926					
Pol	12.53	14.66	13.40	13.03	13.24
Per cent Fiber	12.90	12.24	12.72	12.46	12.65
Purity 1st Expressed Juice	87.59	89.03	86.61	86.68	87.45
Quality Ratio	8.73	7.36	8.23	8.33	8.24
1927					
Pol	11.34	14.00	12.61	12.07	12.32
Per cent Fiber	12.84	11.98	12.29	12.65	12.49
Purity 1st Expressed Juice	86.27	87.85	85.87	85.17	86.28
Quality Ratio	9.73	7.71	8.78	9.11	8.91
1928					
Pol	11.57	14.13	13.09	12.09	12.55
Per cent Fiber	12.58	12.56	12.13	12.82	12.50
Purity 1st Expressed Juice	86.60	88.76	86.84	85.16	86.84
Quality Ratio	9.54	7.55	8.39	9.11	8.72
1929					
Pol	11.80	14.56	13.49	12.64	12.90
Per cent Fiber	12.53	13.24	12.28	12.61	12.62
Purity 1st Expressed Juice	86.65	89.14	87.17	85.97	87.18
Quality Ratio	9.45	7.35	8.14	8.69	8.50
1930					
Pol	11.30	13.77	13.05	12.67	12.49
Per cent Fiber	12.73	12.92	12.35	12.57	12.63
Purity 1st Expressed Juice	86.59	88.60	86.98	86.34	87.04
Quality Ratio	9.84	7.79	8.42	8.55	8.76
1931					
Pol	11.51	14.30	13.17	12.55	12.63
Per cent Fiber	12.52	13.04	11.98	12.75	12.53
Purity 1st Expressed Juice	86.18	88.26	86.31	85.49	86.47
Quality Ratio	9.66	7.52	8.42	8.73	8.72
1932					
Pol	11.16	14.02	13.23	12.35	12.42
Per cent Fiber	12.44	13.06	12.29	12.63	12.56
Purity 1st Expressed Juice	86.25	88.71	87.15	85.69	86.86
Quality Ratio	10.05	7.63	8.27	8.89	8.84

TREND IN CANE QUALITY 1918—1932

	Quality Ratio	Yield Per Cent Cane
Maui	+ .19	— .35
Oahu	+ .44	— .62
Kauai	+ .60	— .80
Hawaii	+1.18	—1.30
Average	+ .69	— .94

When we consider that between 35 and 40 per cent of the total cane tonnage is on Hawaii, it is apparent that decreases in quality on that island have been responsible for fully one-half of the decrease in the average quality of cane.

While studying data on cane quality during this period, it was noted that there has been a fairly well defined tendency for fluctuations in quality to follow recurring cycles of approximately five years each.

Chemical Control

The introduction of the Oliver-Campbell filter into the industry with the attendant use of screened bagasse as a filter aid brings up the question of accounting for the sugar in this bagasse. This sugar has already been accounted for in the loss in bagasse and if it again appears as a part of the loss in filter cake, we have a duplication of losses with a corresponding error in undetermined loss.

Determining the amount of sugar thus introduced is somewhat troublesome. The screened bagasse is not weighed, rendering it necessary to estimate the weight indirectly from fiber determinations. Also it is higher in moisture and lower in pol than the average bagasse, rendering separate analyses necessary. Careful determinations throughout the season at Koloa indicate that it amounts to about .04 per cent of the pol in cane under conditions at that factory. While the amount of sugar involved is not large, it is a fairly large part of the amount to which the filter cake loss can be reduced with this equipment and an appreciable part of the usual figures for undetermined loss. The loss in filter cake should be corrected for the sugar thus introduced by deducting this sugar from the total in filter cake. Preferably, the determination of this correction should be a part of the regular chemical control, but in view of the small amount of sugar involved, corrections estimated from determinations made periodically may be found sufficiently accurate.

Koloa's data have been corrected for the sugar thus introduced. We have not been informed that a similar correction has been made at other factories using Oliver-Campbell equipment.

Comparisons of actual and theoretical boiling house recoveries based on sucrose are in Table 3. The usual table based on pol has been omitted, figures for the three factories from which sucrose data have not been received being included in Table 3 with the notation that they are calculated from pol data.

There is little change in the tendency to report high figures for recovery on available. Twenty-one of the 38 factories report over 100 per cent. Four of the factories on a sucrose basis report over 101 per cent.

TABLE NO. 3

TRUE BOILING-HOUSE RECOVERY

Comparing per cent sucrose available and recovered

Factory	Available	Obtained	% Recovery on Available	Molasses Produced on Theoretical	
				s. j. m. Formula	Gravity Solids*
H. C. & S. Co.	93.05	93.82	100.8	86.0	90.3
Oahu	93.10	93.71	100.7	90.0	95.2
Ewa	92.54	92.62	100.1	95.3	96.3
Waialua	92.49	92.88	100.4	83.2	85.9
Maui. Agr.	93.09	93.85	100.8	86.1	88.0
Pioneer	92.81	91.35	98.4	102.2	97.0
Lihue	91.38	91.39	100.0	90.0	91.1
Olaa	91.63	91.14	99.5	96.7	95.4
Haw. Sug.	93.25	93.75	100.5	94.2	98.1
Kekaha	92.43	90.31	97.7	93.8	86.5
Honolulu	93.02	89.83	96.6	99.6	85.3
Haw. Agr.	92.32	90.37	97.9	104.3	96.0
Onomea	91.28	92.03	100.8	88.8	92.1
Hilo	90.57	90.05	99.4	86.5	85.3
Honokaa†	88.06	88.80	100.8	....	89.5
Makee	89.61	88.59	98.9	85.2	82.6
McBryde	90.95	90.22	99.2	92.6	91.3
Wailuku	92.58	92.57	100.0	91.0	92.6
Hakalau	91.81	92.23	100.5	91.5	93.4
Kahuku	91.48	92.76	101.4	88.0	....
Laupahoehoe	93.16	92.88	99.7	88.2	87.2
Koloa	91.94	92.19	100.3	92.2	93.9
Waiakea	90.41	91.25	100.9	83.5	87.6
Hamakua	91.44	93.51	102.3	81.8	90.9
Pepeekeo	91.06	91.48	100.5	93.1	93.6
Hutchinson	91.94	92.89	101.0	83.4	87.6
Paauhau	89.75	88.32	98.4	99.1	94.1
Kohala (Hawi)	88.83	89.54	100.8	83.4	86.9
Kohala	89.42	88.42	98.9	101.0	97.9
Honomu	91.15	92.56	101.5	85.0	90.8
Kaiwiki	89.85	88.80	98.8	100.8	96.1
Waimanalo	88.17	88.48	100.4	88.9	90.1
Kilauea	86.40	86.03	99.6	87.6	88.9
Waianae	92.96	91.32	98.2	91.3	85.1
Kaeleku†	87.32	91.81	105.1	....	91.2
Union Mill	90.36	89.59	99.1	88.9	86.3
Niulii	88.15	86.71	98.4	77.7	75.1
Waimea†	90.13	86.77	96.3	....	76.5

* The theoretical amount of gravity solids in final molasses assumed to be gravity solids in syrup, less solids accounted for in commercial sugar.

† As sucrose in syrup and sugar have not been reported, gravity purities have been estimated by adding 0.8 and 0.3 to the apparent purities of syrup and sugar.

TABLE NO. 4

GRAVITY SOLIDS AND SUCROSE BALANCES

Factory	GRAVITY SOLIDS PER 100 GRAVITY SOLIDS IN MIXED JUICE				SUCROSE PER 100 SUCROSE IN MIXED JUICE			
	Filter Cake	Commercial Sugar	Final Molasses	Undetermined	Filter Cake	Commercial Sugar	Final Molasses	Undetermined
H. C. & S. Co.	4.7	80.2	13.6	1.5	0.54	93.31	5.98	0.17
Oahu	5.3	78.5	15.1	1.1	0.19	93.53	6.21	0.07
Ewa	6.8	75.5	17.0	0.7	0.25	92.39	7.11	0.25
Waialua	4.4	78.3	14.7	2.6	0.22	92.68	6.25	0.85
Maui Agr.	..	83.8	14.3	1.9	...	93.85	5.95	0.20
Pioneer	5.1	76.5	17.6	0.8	0.25	91.12	7.35	1.28
Lihue	4.7	75.0	18.4	1.9	0.45	90.98	7.76	0.81
Olaa	4.0	76.6	18.4	1.0	0.14	91.01	8.09	0.76
Haw. Sug.	3.5	80.2	15.8	0.5	0.12	93.64	6.37	—0.13
Kekaha	3.8	77.4	16.0	2.8	0.22	90.11	7.10	2.57
Honolulu	5.4	75.6	16.3	2.7	0.40	89.47	6.95	3.18
Haw. Agr.	2.8	77.7	18.7	0.8	0.26	90.14	8.01	1.59
Onomea	4.5	76.7	17.3	1.5	0.08	91.96	7.74	0.22
Hilo	5.4	73.5	17.9	3.2	0.27	89.81	8.16	1.76
Makee	5.4	71.2	19.3	4.1	0.46	88.18	8.85	2.51
McBryde	4.5	73.3	20.1	2.1	0.44	89.82	8.38	1.36
Wailuku	4.9	78.6	15.1	1.4	0.49	92.12	6.75	0.64
Hakalau	4.8	76.7	17.3	1.2	0.15	92.09	7.49	0.27
Kahuku	..	...	...	..	0.26	92.52	7.50	—0.28
Laupahoehoe	3.1	79.5	15.1	2.3	0.13	92.76	6.03	1.08
Koloa	5.2	75.1	18.4	1.3	0.17	92.03	7.43	0.37
Waiakea	5.0	74.7	17.6	2.7	0.53	90.77	8.01	0.69
Hamakua	..	80.4	17.8	1.8	...	93.51	7.00	—0.51
Pepeekeo	6.4	73.4	19.2	1.0	0.29	91.21	8.32	0.18
Hutchinson	5.0	76.7	15.9	2.4	0.12	92.78	6.72	0.38
Paauhau	5.7	73.1	20.0	1.2	0.73	87.68	10.16	1.43
Kohala (Hawi)	6.5	70.8	19.6	3.1	0.92	88.72	9.32	1.04
Kohala	5.1	71.8	22.7	0.4	0.68	87.82	10.69	0.81
Honomu	6.6	74.8	16.8	1.8	0.31	92.27	7.52	—0.10
Kaiwiki	4.1	74.7	20.6	0.6	0.66	88.21	10.23	0.90
Waimanalo	6.2	68.9	22.5	2.4	0.54	88.00	10.52	0.94
Kilauea	5.0	66.9	24.7	3.4	1.38	84.84	11.92	1.86
Waianae	4.1	78.0	15.1	2.8	0.37	90.98	6.43	2.22
Union Mill	7.1	72.4	17.7	2.8	0.27	89.35	8.57	1.81
Niulii	4.1	71.3	18.4	6.2	0.99	85.85	9.21	3.95

Factory	Cane Sucrose	MIXED JUICE		SYRUP		SUGAR		Undetermined Loss per 100 Sucrose in cane
		Sucrose	Gravity Purity	Gravity Purity	Increase in Purity	Sucrose	Sucrose per 100 Sucrose in cane	
H. C. & S. Co.	14.59	12.31	88.54†	88.54	0	98.23	91.43	0.16
Oahu	13.73	11.72	86.64	87.36	0.72	98.36	92.07	0.07
Ewa	13.60	11.58	84.16	86.5	1.34	98.48	90.69	0.24
Waialua	13.57	11.65	85.7	87.3	1.6	98.50	90.99	0.83
Maui Agr.	14.61	12.35	88.03†	88.31	0.28	98.16	91.77	0.19
Pioneer	13.76	12.09	85.32	86.85	1.53	97.99	89.15	1.25
Lihue	11.71	10.76	83.6	84.9	1.3	98.20	88.56	0.79
Olaa	11.40	10.48	85.3	86.7	1.4	98.46	88.37	0.74
Haw. Sug.	14.49	12.03	86.05	87.71	1.66	98.56	91.83	—0.13
Kekaha	13.70	12.29	87.03	88.0	0.97	98.31	87.65	2.50
Honolulu	14.27	12.06	86.95	89.0	2.05	100.0	87.33	3.11
Haw. Agr.	11.97	10.77	86.57	87.26	0.69	98.23	87.75	1.54
Onomea	11.11	9.41	84.18	86.06	1.88	98.14	90.37	0.21
Hilo	10.93	9.80	83.69	84.9	1.21	97.76	87.96	1.73
Makee	11.58	10.16	82.3	83.77	1.47	97.96	84.72	2.41
McBryde	11.86	9.82	82.18	83.76	1.58	97.92	87.77	1.32
Wailuku	13.52	11.03	86.9	88.4	1.5	98.50	90.76	0.63
Hakalau	10.72	9.07	84.38	85.8	1.42	97.44	90.68	0.27
Kahuku	11.30	10.18	81.99	84.75	2.76	98.7	90.45	—0.27
Laupahoehoe	11.92	10.44	86.93	87.48	0.55	98.63	90.40	1.05
Kolóa	11.67	9.77	83.08	84.97	1.89	98.44	89.63	0.36
Waiakea	11.58	10.01	83.54	85.17	1.63	98.34	88.09	0.67
Hamakua	11.37	10.86	84.98†	84.64	—0.34	98.36	90.74	—0.50
Pepeekeo	11.14	10.16	82.37	84.75	2.38	98.51	89.05	0.18
Hutchinson	11.90	10.22	84.08	85.29	1.21	97.55	90.56	0.37
Paauhau	11.04	9.80	83.98	85.7	1.72	96.96	85.38	1.39
Kohala (Hawi)	11.20	10.53	81.19	83.55	2.36	98.22	86.61	1.02
Kohala	11.41	10.04	82.77	84.56	1.79	98.45	85.15	0.78
Honomu	11.08	9.10	83.59	85.42	1.83	98.22	90.26	—0.10
Kaiwiki	12.12	11.77	85.49	86.51	1.02	98.02	85.03	0.86
Waimanalo	11.54	9.68	79.28	81.38	2.10	97.33	86.70	0.93
Kilauea	10.43	9.81	79.76	80.41	0.65	97.57	81.16	1.78
Waianae	14.28	12.56	86.21	87.67	1.46	97.85	88.74	2.16
Union Mill	11.13	10.91	83.41	85.69	2.28	97.86	83.46	1.69
Niulii	10.10	9.73	84.02	84.85	0.83	98.35	80.17	3.69
‡True Average 1932	12.60	11.00	85.15	86.46	1.31	98.22	89.48	0.74
" " 1931	12.75	11.17	84.74	85.78	1.04	98.05	88.61	0.89
" " 1930	12.67	11.08	85.35	86.49	1.14	98.05	88.90	0.89
" " 1929	13.08	11.44	85.58	86.60	1.02	98.00	88.75	1.05
" " 1928	12.69	11.22	85.15	86.23	1.08	97.86	88.49	1.21
" " 1927	12.46	11.01	84.53	85.86	1.33	97.79	87.96	1.13
" " 1926	13.35	11.68	85.38	86.66	1.28	97.67	88.41	1.20

*Sucrose in bagasse and filter cake is assumed to be the same as pol.
†Clarified juice. ‡Refinery data from Honolulu not included in averages.

Both sets of calculations of molasses produced on the theoretical are in Table 3. Averages indicate a slight tendency toward an increase in molasses production per cent theoretical in the past few years. This year the average, calculated with the s. j. m. formula, is 91.3. On the gravity solids basis the average is 91.1. Last year the averages were 90.6 and 89.0 respectively. Data for individual factories vary to about the usual extent.

The new divisor for calculating sucrose, adopted when the Methods of the Association of Hawaiian Sugar Technologists were revised in 1931, was substituted for the Herzfeld divisor at the beginning of the season. Soon afterward it became apparent that sucrose determinations were too low. About June 1, a change back to the Herzfeld divisor was made and data were recalculated to the old basis so that sucrose figures for this season would be on the same basis as in previous years. Average differences between pol and sucrose in mixed juice and syrup are practically the same as last season, but the changes in the divisor have caused an irregularity in sucrose in sugar, the average appearing to be approximately .1 too high in comparison with data for previous years.

Unsatisfactory results with the new sucrose divisor were caused by two inaccuracies rather than by the divisor itself. The temperature correction factor in the sucrose formula, which had been continued unchanged, is not correct, and pipettes customarily used for measuring out the portion of the solution for the inversion do not deliver the full volume on account of the viscosity of the solution. These two factors offset about a half of the known error in the Herzfeld divisor and cause low results when a more nearly correct divisor is used.

Gravity solids and sucrose balances for factories reporting sucrose data are in Table 4. None of the factories has reported a negative undetermined loss of solids; an improvement over the two previous seasons. On the other hand, negative undetermined losses of sucrose appear in data for four factories, a larger number than in previous years. The increase is probably caused by errors in sucrose in commercial sugar associated with changes in the sucrose divisor, discussed in a preceding paragraph.

Sucrose data with true averages, for comparison with pol data in the large table, are in Table 5.

The difference between undetermined loss based on sucrose and the undetermined loss based on pol for factories included in Table 5 is .71. Taking into consideration the probable discrepancy in the average for sucrose in commercial sugar, the difference becomes .81. Applying this correction to the undetermined loss in the large table gives a corrected figure for all factories of .88. During the seven seasons in which the correction has been thus determined, it has varied between a maximum of .93 and a minimum of .81 with an average of .84. We can thus accept between .8 and .9 as the approximate correction to add to the undetermined loss when examining balances based on pol.

With reference to data submitted:

Pol data have been reported from all factories.

Sucrose in molasses has been reported from all factories for the first time.

Other sucrose data have been reported from 35 of the 38 factories.

Molasses weights have been reported from 32 factories and weights calculated from measurements from the remaining six. This is the first season that data on the quantity of molasses have been reported from all factories.

pH data for hot limed juice, clarified juice and syrup have been reported from all factories. This is the first season that these data have been complete.

Turbidity of clarified juice has been reported from 33 factories.

Milling

Milling has attained a new high mark. For the first time the extraction is above 97.5, extraction ratio below 20, and milling loss below 2.5. Bagasse pol is considerably lower than in any previous season, while bagasse moisture equals the previous record made last season. Improvements in milling are reported from about two-thirds of the factories.

The trend has been toward better results during the past five or six years. This is the third successive season in which a new record has been made for milling loss, but the first season in which extraction has exceeded the record made in 1920. Decreases in cane pol, which amount to 1.22 since 1920, have made it more difficult to attain high extractions. Had cane pol remained as high as in 1920, without doubt the extraction record of that year would have been exceeded prior to this season.

The average grinding rate for mills now in operation has increased approximately half a ton. Averages in the large table for tons of cane ground per hour indicate an increase of .92, but these figures are misleading as the 1932 average has been increased by the omission of data from Olowalu, a factory with a low grinding rate which is no longer operated.

Data for imbibition per cent cane disclose a small trend toward an increase during the past four or five years, notwithstanding appreciable increases in grinding rate. An increase of .56 in imbibition this year brings the average to 33.75 per cent. While considerably lower than in some preceding years, this is the highest average since 1924.

The trend toward higher pressure continues. The average reported per foot of roller is now 70.8 tons, an increase of half a ton over last season. The total increase during the 11 seasons for which data have been compiled is 5.6 tons per foot of roller.

Additions to milling machinery consist of replacing two roller crushers with three roller units at Laupahoehoe and Waiakea. Improvements over last season in extraction amounting to .56 and .92 respectively have been realized. These increases are equivalent to a quarter of the increase in the average for extraction. On the other hand, suspending factory operations at Olowalu has made a reduction in the amount of milling machinery. As the extraction at Olowalu was higher than the extraction secured at Pioneer, where the cane is now ground, this has tended to depress the average extraction and thus has partially offset the influence of the additions to milling machinery on this average.

In summing up, reported data disclose two factors, higher grinding rate and lower pol in cane which have influenced extraction adversely, and three factors

TABLE NO. 6—MILLING RESULTS

Showing the rank of the factories on the basis of milling loss.

Rank	1931 Rank	Factory	Milling Loss	Extraction Ratio	Extraction	Imbibition % Cane	Tonnage Ratio	Tonnage Fiber Ratio
1	1	Waimanalo.....	1.33	11.7	98.51	38.12	1.95	24.9
2	2	Hakalau.....	1.40	13.3	98.44	36.54	1.81	21.3
3	4	Wailuku.....	1.66	12.4	98.51	40.47	1.32	15.9
4	3	Onomea.....	1.66	15.1	98.25	36.20	2.22	25.7
5	7	Hilo.....	1.76	16.2	97.92	31.40	1.97	25.3
6	8	Oahu.....	1.86	13.8	98.42	34.84	1.84	21.2
7	23	Waialua.....	1.93	14.3	98.15	36.97	2.21	28.4
8	6	Ewa.....	1.99	14.1	98.13	38.51	1.60	21.2
9	11	McBryde.....	1.99	17.0	97.68	40.65	1.46	19.9
10	5	Honomu.....	2.04	18.7	97.81	39.65	1.51	17.7
11	15	Kohala (Hawi).	2.04	18.3	97.61	26.56	2.13	27.8
12	13	Pepeekeo.....	2.07	18.8	97.62	27.98	1.85	23.4
13	9	Paauhau.....	2.10	19.3	97.35	33.82	1.12	15.4
14	10	Kahuku.....	2.11	19.0	97.72	28.22	1.70	20.3
15	12	Haw. Sug.....	2.17	15.2	98.04	39.72	1.80	23.3
16	14	Pioneer.....	2.24	16.5	97.81	34.98	2.47	32.8
17	17	H. C. & S. Co..	2.25	15.5	97.96	37.69	1.74	23.4
18	19	Koloa.....	2.40	20.9	97.36	38.21	1.39	17.6
19	16	Maui Agr.....	2.48	17.1	97.77	37.97	1.89	24.6
20	18	Hutchinson.....	2.50	21.2	97.58	33.09	1.93	21.9
21	26	Lihue.....	2.53	21.9	97.31	28.40	2.39	29.3
22	20	Waimea.....	2.55	18.4	97.68	36.31	1.66	20.8
23	29	Laupahoehoe...	2.57	21.8	97.43	31.31	1.97	23.2
24	27	Olaa.....	2.59	22.8	97.08	29.19	2.45	31.3
25	31	Waiakea.....	2.65	23.3	97.00	36.11	1.92	24.8
26	24	Haw. Agr.....	2.76	23.4	97.31	29.09	2.04	23.4
27	25	Hamakua.....	2.81	24.8	97.02	33.05	1.53	18.4
28	28	Kohala.....	2.89	25.7	96.92	30.96	1.67	20.1
29	21	Honolulu.....	2.91	20.6	97.58	35.32	1.53	18.0
30	22	Waianae.....	3.13	22.2	97.51	29.65	1.70	19.1
31	30	Kekaha.....	3.14	23.2	97.23	29.83	2.39	28.4
32	32	Kilauea.....	3.22	31.3	95.61	27.14	1.62	22.8
33	34	Kaiwiki.....	3.51	29.2	96.36	20.93	1.78	22.2
34	33	Makee.....	3.63	31.9	96.02	31.64	2.22	27.7
35	35	Honokaa.....	3.99	39.1	94.73	34.41	1.67	22.5
36	36	Kaeleku.....	4.10	36.2	95.02	37.18	1.82	25.0
37	38	Niulii.....	4.87	48.6	93.34	23.01	2.04	28.0
38	37	Union Mill.....	5.24	47.5	93.33	21.18	1.70	23.8

increased imbibition, heavier pressure and additions to milling machinery, which have had a favorable influence.

The purity difference between first expressed and mixed juice (Table 7) is 2.91. While this is .02 larger than last season, smaller differences have been recorded in but three previous seasons.

No factory has come particularly close to equalling previous records at individual factories in extraction, extraction ratio or milling loss, nor is the number of factories reporting over 98 extraction as large as in several previous seasons. The number reporting under 2.0 milling loss equals the previous record of 9 made last year.

The usual ranking of factories according to milling loss, with a summary of the more important milling figures, is in Table 6. A material improvement at Waialua has advanced this factory from 23 to 7. The improvement follows a decrease in grinding rate and heavier imbibition. Following the installation of new milling equipment, Waiakea and Laupahoehoe have each advanced 6 in relative rank. Lihue has advanced 5. Following an increase in grinding rate, Honolulu has dropped 8 in relative rank. Waianae also has dropped 8, and Honomu 5.

Boiling House Work

Marked improvements have been made in this department as well as in milling. As a result, new records have been established for final molasses purity and overall recovery, and the boiling house recovery is higher than in any year since Synopsis data have been reasonably complete.

Recoveries have been favored somewhat by an improvement over last season in juice purities, the improvement in the purity of the first expressed juice amounting to .39. While better than last season, juice purities are lower than in the two preceding years.

Clarification: Another factor contributing to higher recoveries this season is as unusually large increase in purity from mixed juice to syrup. Data in Table 7 indicate an improvement of .30 over last season. The average increase in purity, 1.66, was equalled in 1927, but with this exception it is considerably better than in any recent year. With the better purity increase in clarification, the improvement over last season in syrup purity is .64.

The decrease from 7.99 to 7.93 in the average pH of the hot limed juice is misleading, data for one large factory from which pH of the hot limed juice had not been reported previously having depressed the average to this extent. The average for the other factories is identical with the average of last season.

Averages for turbidity of clarified juice are also misleading. Although the average has decreased from 3.41 to 3.33, examination of data does not disclose a general tendency toward poorer turbidity. Including data from two factories from which turbidity had not been reported previously and excluding one factory previously included which did not report this year, together with much poorer turbidity reported from one large factory have depressed the average to a greater extent than the difference between averages for the two seasons. Averaging data from other factories reporting turbidity in both seasons indicates a small improve-

TABLE NO. 7

True averages of factories basing control on mixed juice.

	1927	1928	1929	1930	1931	1932
First Expressed Juice—						
Brix	17.17	17.45	17.76	17.36	17.57	16.74
Pol	14.74	15.08	15.40	15.04	15.13	14.48
Purity	85.84	86.41	86.69	86.68	86.10	86.47
"Java ratio"	81.7	81.6	82.1	81.5	81.8	82.0
Mixed Juice—						
Brix	12.88	13.04	13.29	12.98	13.13	12.75
Pol	10.67	10.89	11.15	10.87	10.93	10.65
Purity	82.88	83.47	83.89	83.73	83.21	83.56
Weight % cane	109.71	109.87	110.18	109.77	110.28	108.62
Extraction	97.23	97.24	97.28	97.25	97.36	97.49
Extraction ratio	22.1	22.1	21.7	21.8	21.2	20.6
Last Expressed Juice—						
Pol	1.88	1.94	1.99	1.94	2.01	1.84
Purity	67.76	68.39	68.73	68.54	68.19	67.71
Imbibition water % cane.	32.04	31.99	32.44	32.15	32.23	32.59
Syrup—						
Brix	62.91	63.05	63.38	64.09	64.16	64.38
Purity	84.54	84.86	85.24	85.17	84.57	85.22
Increase in purity	1.66	1.39	1.35	1.44	1.36	1.66
Lbs. avail. CaO per ton cane	1.52	1.46	1.38	1.30	1.37	1.23
Filter Cake—						
Pol	2.22	2.34	2.27	1.82	1.65	1.20
Weight % cane	2.67	2.87	2.87	2.96	2.99	3.23
Pol % pol of cane	0.49	0.55	0.52	0.44	0.40	0.33

ment over last year, with an equal number of factories reporting better and poorer turbidities.

The amount of lime has decreased. The average, expressed as pounds available CaO per ton cane, is 1.25, against 1.37 in 1931 and 1.32 in 1930.

Filtration: Losses in filter cake have been reduced materially, an increase in the quantity of press cake having been much more than offset by a large decrease in pol. The loss in press cake per cent pol in cane (Table 7) has been reduced from .40 to .33, the lowest figure since 1921.

The improvement may be credited to Oliver-Campbell filters. If the factories using vacuum filters had reported the same loss in filter cake as last year, instead of the large reduction, there would have been a small increase in the average loss in filter cake. The increase in the quantity of filter cake is likewise attributable to this equipment.

Handling settlings with filters of the vacuum drum type is a comparatively recent innovation. Its practicability was first demonstrated on a factory scale at Oahu Sugar Company in 1926 by the late Mr. John F. Borden, a man who contributed much to improvements in the art of filtration. With further improvements by Mr. R. C. Campbell, which include modifications in design and utilizing screened bagasse as a filter aid, equipment is now available which will filter settlings at a high capacity and with which the loss in filter cake can be reduced to a very low point. While this has entailed some sacrifice in the clearness of the filtrate, in view of improvements made in the comparatively short period of seven

years, it would be rash to predict that this deficiency will not be ameliorated or corrected.

Filters of this type are now installed in six Hawaiian factories. The original installations at Oahu and Olaa were Olivers. At Oahu, screens were substituted for cloth in 1929. At Olaa, the original drums were replaced with Oliver-Campbell drums and bagasse sifting equipment was installed during the 1931 season. Installations at the other four factories are Oliver-Campbell equipment. At Kekaha, one unit was installed during the 1931 season and a second unit during 1932. At Koloa, a filter was installed prior to the 1932 season; at Ewa and Honokaa, filters were installed during the 1932 season. Material reductions in filter cake loss over previous practice have been realized at all of these factories except Honokaa, and at this factory the loss was materially reduced while the filter was in operation.

In addition to reducing the loss in filter cake, the Oliver-Campbell equipment should render it practicable to screen the cush-cush from the mixed juice thoroughly. This should be a material advantage, for allowing considerable amounts of cush-cush to pass through the clarification for the purpose of making the settlings filterable is a decidedly undesirable feature of our present practice.

Evaporation: The average density of the syrup has increased from 64.15 to 64.64, the highest figure on record. No additions to evaporator equipment have been reported. With a higher grinding rate, an increase in the percentage of mixed juice on cane, and the lowest mixed juice density on record, the increase in the calculated amount of water evaporated per hour is 3.1 per cent greater than last season.

Commercial Sugar: The pol of the sugar has increased for the thirteenth successive season, bringing the average to 97.76. The increase has been principally among factories in the Crockett group, the average for these factories being 97.86 against 97.78 last year. The average pol for other factories is 96.97 against 96.96.

The average deterioration factor has reached a new low point, .227. Four factories, however, report deterioration factors in excess of .25, an increase of one over last season.

Final Molasses: The new record for final molasses purity is 35.90, an improvement of .42 over the previous record of last season. A decrease in the purity of the low grade sugar has accompanied the improvement in molasses purity. We might note that in visualizing the effect of decreases in molasses purity, we may consider that under average conditions a decrease of 3 in molasses purity corresponds to an increase of 1 per cent or slightly more in sugar production.

Decreases in molasses purity are reported from 23 factories and increases from 14.

Koloa leads with 32.62 purity. This, however, does not equal the record for an individual factory of 31.81 made at Kahuku in 1927.

Factories are listed below in the order of the final molasses purity together with the relative rank in 1931.

GRAVITY PURITY FINAL MOLASSES

Rank 1932	Rank 1931	Factory	Gravity Purity
1	4	Koloa	32.62
2	1	Kahuku	33.13
3	2	Hamakua	33.37
4	6	McBryde	33.50
5	3	Ewa	33.75
6	11	Laupahoehoe	33.80
7	9	Oahu	34.07
8	5	Haw. Sugar	34.15
9	10	Hutchinson	34.21
10	17	Lihue	34.3
11	12	Pepeekeo	34.43
12	7	Pioneer	34.48
13	13	Hakalau	35.48
14	22	Waialua	35.62
15	14	Honomu	35.90
16	16	Waimanalo	35.90
17	8	Waianae	35.91
18	21	Honolulu	36.10
19	20	Haw. Agr.	36.45
20	26	Makee	36.50
21	15	Maui Agr.	36.66
22	24	Hilo	36.7
23	34	Olaa	36.77
24	23	Onomea	36.79
25	18	Waiakea	36.95
26	19	H. C. & S.	37.19
27	35	Kilauea	37.38
28	31	Kohala (Hawi)	37.53
29	30	Kekaha	37.65
30	29	Wailuku	37.83
31	27	Kohala	38.01
32	25	Honokaa	38.35
33	38	Union Mill	38.64
34	32	Kaeleku	39.55
35	37	Niulii	41.26
36	33	Paauhau	41.29
37	36	Kaiwiki	41.43
38	..	Waimea	42.12

Changes of five places or more in relative rank are as follows: Increases, Olaa 11, Waialua 8, Kilauea 8, Lihue 7, Makee 6, Laupahoehoe 5, and Union Mill 5, and decreases, Waianae 9, H. C. and S. 7, Honokaa 7, Waiakea 7, Maui 6, and Pioneer 5.

At Union Mill new crystallizers and centrifugals have been installed and the low grade pan has been rebuilt. A reduction of 6.42 in molasses purity has been realized. This is the largest improvement at any factory. Improvements of 2.83 at Olaa and 1.60 at Hawi have also been realized, following additions to the low grade centrifugal equipment.

Recovery

As noted in a previous paragraph, the overall recovery, 89.82, is a new record. It is .49 higher than the previous record made in 1930 and .65 higher than the recovery of last year.

It is quite probable that the boiling house recovery also is actually higher than has been attained previously, although the average, 92.09, does not equal figures recorded for 1907 and 1909. If data had been reported from all factories, or indeed, if chemical control had then been as reliable as at present, there is little doubt but that lower averages than the present boiling house recovery would be recorded for these years.

Improvements over last season in recovery are due in part to better juice purity. This accounts for .29 of the .65 increase in overall recovery. The difference, .36, is equivalent to a .44 per cent improvement over the recovery of last year, attributable to better results in the factory. Better purity increase in clarification and lower molasses purity account for the greater part of the improvement, with higher extraction, lower loss in filter cake and lower undetermined loss as contributing factors. These have been offset to a slight extent by the increase in the pol of the sugar.

Calculations based on quality ratio, in which yields of sugar per cent cane corresponding to quality ratio are compared with sugar production per cent cane,

indicate about the same percentage of improvement attributable to better results in the factory. In 1931 sugar production was 100.02 per cent of that indicated by quality ratio. This year production was 100.53 per cent, an improvement of .51 per cent against the .44 per cent indicated by the usual control figures.

In the Synopsis of 20 years ago, Noel Deerr remarked that—"though we obtain here over all a larger recovery than elsewhere, it is still possible to increase this margin further, and to add, I believe, 5 per cent to the output from a given weight of cane." If we modify his wording to meet the lower quality of cane that has accompanied the higher cane yields which we now enjoy, we might count him as having predicted a 5 per cent increase in the output from a given weight of sugar in the cane. Thus construed, the prediction has been liberally fulfilled, for this year the output from a given weight of sugar in the cane is 5.73 per cent greater than when he made his forecast. This has been accomplished in spite of handicaps imposed by decreases in cane pol and in juice purity. Were we handling cane of the same characteristics as the cane of 20 years ago, the predicted increase would now be exceeded by a considerably wider margin.

Calculations in this Synopsis have been made by Mr. Brodie, assisted by Mr. Ashton and others of this department.

TABLE NO. 8

COMPARISON OF ACTUAL AND THEORETICAL RECOVERIES

Recovery % Calculated Recovery *					Recovery % Recovery Indicated by "Sugar Ratio" †	
Rank	Factory	Milling	Boiling House	Over All	Rank	Over All
1	Kahuku	97.72	104.86	102.77	1	103.61
2	Hamakua	97.02	104.04	101.45	12	99.93
3	Oahu	98.42	102.70	101.36	2	101.73
4	Koloa	97.36	103.34	101.01	8	100.43
5	Hutchinson	97.58	102.93	100.76	9	100.15
6	Haw. Sug	98.04	102.44	100.71	3	101.14
7	Honomu	97.81	102.61	100.66	7	100.44
8	Hakalau	98.44	101.86	100.63	6	100.50
9	Ewa	98.13	102.22	100.56	4	100.89
10	Waimanalo	98.51	101.20	99.97	19	98.91
11	McBryde	97.68	101.97	99.96	10	100.11
12	Onomea	98.25	101.23	99.77	5	100.61
13	Lihue	97.31	101.85	99.50	14	99.72
14	Maui Agr	97.77	101.33	99.49	13	99.82
15	Pepeekeo	97.62	101.66	99.44	15	99.48
16	Waialua	98.15	100.97	99.36	11	100.10
17	Waiakea	97.00	101.79	99.17	21	98.57
18	Kohala (Hawi)	97.61	100.17	99.15	22	98.03
19	Laupahoehoe	97.43	101.39	99.00	18	99.04
20	Wailuku	98.51	100.02	98.78	16	99.46
21	Pioneer	97.81	100.52	98.64	20	98.70
22	H. C. & S. Co	97.96	100.33	98.57	17	99.17
23	Kaeleku	95.02	102.60	97.90	25	97.71
24	Hilo	97.92	99.55	97.76	27	97.56
25	Haw. Agr	97.31	99.84	97.46	24	97.81
26	Waianae	97.51	99.56	97.31	23	97.83
27	Olaa	97.08	99.61	97.13	26	97.57
28	Makee	96.02	100.34	96.91	31	96.56
29	Honolulu	97.58	97.98	95.83	29	96.93
30	Kohala	96.92	98.53	95.79	30	96.60
31	Kekaha	97.23	98.07	95.71	28	97.00
32	Kilauea	95.61	98.94	95.07	32	94.48
33	Honokaa	94.73	99.64	94.90	33	94.44
34	Paauhau	97.35	96.80	94.60	34	94.34
35	Kaiwiki	96.36	96.91	93.67	35	93.45
36	Union Mill	93.33	99.45	93.14	36	93.43
37	Waimea	97.68	94.00	92.11	37	92.22
38	Niulii	93.34	95.47	89.57	38	88.90

* Factories are arranged in the order of the ratio of their recovery to that calculated on the basis of 100% extraction, 37.5 gravity purity molasses and no other losses.

† The basis of this calculation is 98 extraction, syrup purity one less than the apparent purity of the first expressed juice, sugar purity 98, gravity purity of molasses 33.33 and no other losses.

Sugar Prices

96° CENTRIFUGALS FOR THE PERIOD
SEPTEMBER 21, 1932, TO DECEMBER 15, 1932

Date	Per Pound	Per Ton	Remarks
Sept. 21, 1932	3.15¢	$63.00	Porto Ricos.
" 23	3.14	62.80	Cubas.
" 27	3.135	62.70	Philippines, 3.13; Cubas, 3.14.
" 28	3.145	62.90	Porto Ricos, 3.14, 3.15.
" 29	3.18	63.60	Philippines.
Oct. 1	3.16	63.20	
" 4	3.15	63.00	Cubas.
" 5	3.14	62.80	Cubas.
" 7	3.16	63.20	Porto Ricos.
" 10	3.18	63.60	Porto Ricos.
" 13	3.20	64.00	Cubas, Porto Ricos.
" 14	3.175	63.50	Cubas, 3.17, 3.18.
" 17	3.155	63.10	Cubas, 3.15, 3.16.
" 21	3.13	62.60	Porto Ricos, 3.14; Cubas, 3.12.
" 24	3.12	62.40	Cubas.
" 25	3.10	62.00	Porto Ricos, Cubas.
" 26	3.085	61.70	Cubas, 3.08, 3.09.
" 27	3.07	61.40	Cubas.
" 28	3.05	61.00	Cubas, 3.04, 3.05, 3.06.
Nov. 2	3.10	62.00	Porto Ricos, Philippines, Cubas.
" 4	3.12	62.40	Cubas.
" 12	3.15	63.00	Porto Ricos, Philippines.
" 14	3.13	62.60	Cubas.
" 15	3.11	62.20	Cubas, 3.10, 3.12.
" 16	3.10	62.00	Cubas.
" 18	3.08	61.60	Cubas.
" 22	3.015	60.30	Cubas, 3.03; Philippines, 3.00.
" 25	3.00	60.00	Cubas.
" 28	2.95	59.00	Cubas.
" 29	2.92	58.40	Cubas.
" 30	2.885	57.70	Philippines, 2.90; Cubas, 2.87.
Dec. 2	2.85	57.00	Cubas.
" 8	2.88	57.60	Porto Ricos.
" 9	2.90	58.00	Cubas.
" 13	2.89	57.80	Cubas, 2.88, 2.90.
" 14	2.85	57.00	Cubas.
" 15	2.82	56.40	Cubas.